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## THE CULTURE VALUE OF PHYSICAL GEOGRAPHY.\*

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For the purpose of discussion, the title may be paraphrased in the form of two questions. Has physical geography any culture value, and, if so, what is it? The answers to these questions depend entirely upon our definition of culture.

A well known dictionary defines culture as "The training, development, or strengthening of the powers, mental or physical, or the condition thus produced; improvement or refinement of mind, morals, or tastes; enlightenment or civilization." A broad and comprehensive definition, surely; but an encouraging one because it is so broad. If physical geography can do any of these things or produce any of these conditions, then it has a culture value.

Does it strengthen the mental powers, and, if so, which ones particularly? As an informational study it is unsurpassed. Its field is so broad that it touches all the other sciences intimately and draws upon them so largely to explain many of the phenomena with which it deals that the good geographer must also be versed in astronomy, physics, chemistry, geology, and zoology. Nor does it touch the physical sciences alone; for it comes into contact with the less exact sciences of sociology, civics, and economics. History and even literature, both sedate and romantic, contribute their quota to its understanding and in turn receive their share of interpretation and explanation.

It is not necessary to illustrate extensively how physical geography gives and takes with the other sciences. As a matter of fact there is only one *science*; and it does not matter whether we teach the nebular hypothesis as astronomy or physical geog-

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\*Read before the Northeastern Ohio Association of Science and Mathematics Teachers, Feb. 15, 1907.

raphy. Nor does it matter whether we call Torricelli's experiment physics or physical geography. To know how a fish breathes or how iron rusts is quite as important to the geographer as to the biologist or the chemist.

But why should the sociologist, the publicist, and the economist know of physical geography?

A sociological experiment of recent date is the attempt to re-populate Palestine by encouraging the Jews to return to the land of their forefathers. Within a few days I have read that funds are being collected to purchase and plant trees in that dry country in order to bring rain to it and make it habitable for a large population. If the promoters of this scheme knew, as the geographer knows, that the lack of trees is the *result* and *not the cause* of the lack of rainfall and that Palestine must ever remain an arid country on account of its location and of its winds, the futility of the scheme would be at once apparent.

Again, the tide of immigration which is now sweeping over our eastern shores and congesting the cities of our northern Atlantic seaboard is a matter of concern to our publicists. To turn this tide toward the open lands of the west and the undeveloped areas of the south seems plausible enough; but those who are to shape its course must know just where to direct it and why they do so, else it will come surging back again from desert lands and fields which cannot absorb it. It is the province of the geographer to inform the publicist where to direct his energies, and the publicist must become a geographer to the extent of knowing why.

That the student of history must be a geographer would seem hardly necessary to prove; yet one has but to read some of the most approved text-books of history to know how adequate, not to say how lame, they are in their attempts to show the geographic influences upon the history which they record.

If the student of history would understand why the Russian Empire is so large, while the countries of south-western Europe are so small, he must know that no natural barrier exists to divide the great plains which stretch from the Arctic ocean to the Black sea. To know the true cause of the downfall of Poland, he must know that it was physically impossible for two nations to exist with no natural division in that great plain from the Ural mountains to the river Vistula. Likewise, it was impossible that two nations could exist in America upon the plains

which are not divided from the Great Lakes to the Gulf of Mexico, nor from the Appalachians to the Rockies.

The annual rise of the Nile in Egypt is familiar to all students of history, but is it too much to say that the majority of them know as little of its cause as did the ancient Pharaohs? Perhaps they are told that it is due to the advance of the equatorial rains over the upper part of its basin; but, unless they understand the causes of equatorial rains and why they advance, they must fail to appreciate as fully as they might one of the most remarkable and at the same time one of the most reasonable consequences of the earth's globular form and of its inclined axis. To know that the Nile rises and to know that it has risen annually since the days of Seti and Rameses is one thing; but to understand how and why it must continue to rise so long as earth and sea and sky shall endure is another and greater thing.

In literature a knowledge of physical geography is necessary to understand and appreciate many of its finest productions. Who can appreciate fully the younger Pliny's description of the eruption of Mt. Vesuvius or Bulwer Lytton's "Last Days of Pompeii" unless he knows something of the causes of volcanic eruptions and of their attendant phenomena?

As an informational study, then, physical geography may claim to contribute largely to that improvement and refinement of mind which we have stated as characteristic of culture.

We may now ask, is physical geography a disciplinary study? Does it strengthen the mental powers as do mathematics or an inflected language? I think it is not claiming too much to state that some of the problems to be solved in physical geography are quite as valuable in a disciplinary way as a proposition in geometry; and they are quite capable of being cast in the familiar form of hypothesis, argument, and conclusion.

To illustrate: Given the broad coastal plain of the Carolinas. Prove that it was once a sea bottom, that its layers of sand, gravel, and clay are the waste of the land washed down from the adjacent continent, and that they have since been uplifted to form a new land surface.

To prove this proposition, the pupil must draw upon his previous knowledge of similar coastal plains just as the geometry student must draw upon his previous propositions to prove his statements. He must follow a logical sequence of events, step

by step, and he must finally get back to the axioms, the self-evident truths of geography based upon his own observations and experience. So too, his definitions must be quite as exclusive and precise as those of the geometry student and his terms just as technical.

If we compare physical geography with an inflected language, we may say that it has its own peculiar vocabulary, its inflections, and its conjugations. It is quite as necessary for the student of physical geography to collect a stock of words peculiar to that science as for the Latin or Greek student to know the meaning of the words he uses; and, what is more, he must learn to know the *thing* by its *name* regardless of an equivalent. A teacher once told me that when I began to *think* in Latin, I would begin to know Latin. So the student will begin to be a geographer when he begins to think in terms of the technical words of that science. Thus, if we say that a *belted coastal plain* is a land surface lying between an *oldland* upland and the sea, that it has a *cuesta* which separates the *coastal lowland* from the *inner lowland*, and that upon the *cuesta* is a *divide* which separates the *consequent* streams of the *outer lowland* from the *obsequent* streams which flow down the *in-facing slope* to the *subsequent* stream which has worked out its valley upon the less resistant rocks of the *inner lowland*, we have given a description which would be "Greek" to the layman but which ought to be perfectly intelligible to the physical geographer, not only because he knows the technical terms but because he has a mental picture of just what has taken place to bring this land form to its present condition.

Land forms may be classified just as definitely as Latin verbs are classified into their four conjugations. Thus, we speak of *narrow*, *broad*, *belted*, and *embayed* costal plains, of *block*, *folded*, *domed*, *subdued*, *worn-down*, and *embayed* mountains, and of *undissected*, *sub-maturely dissected*, *maturely dissected*, and *worn-down* plains. The classifications of land forms are not arbitrary, as is the case with Latin verbs. They are based upon logical differences which are consequences of their age and of the processes of nature which have been at work upon them.

If, now, we grant that physical geography can give the pupil a fund of valuable information and that it can discipline him in scientific habits of thoughts, how can it develop his creative

powers? To create anything he must have imagination. Does physical geography develop the imagination?

It seems to me that a large part of our equipment of maps, globes, pictures, models, and special apparatus is intended to do just that thing. Except for instruments for direct measurement, the whole of our apparatus consists of devices for representing the things we are studying. What is a topographic map but a device for helping the student to form a mental picture of a bit of land surface? We cannot bring a mountain into the class room, nor can we always take the class to a mountain; so we show a picture of the mountain, we make a model of it, we study a contour map of it, we draw a section of it, and then we ask the pupil to imagine what it really looks like. If we ourselves will but recall our impressions when we first saw the mountains, the sea, the Great Lakes, or the Great Plains of the west, we can appreciate how far short of the truth were the pictures of them which we had formed in imagination. Physical geography can do much, however, especially in these days of good apparatus and profusely illustrated text-books, to bring the imagination nearer to the truth.

In the analysis of a land form, the student must picture to his mind all the stages through which it has passed. He must create for himself the scenes which attended its progress through elevation, dissection, tilting, folding, re-submergence, and perhaps a re-elevation, glaciation, and volcanic changes—all these and more, until the present form is attained. Then he may go on in imagination and predict its possible future. His speculation will not be idle, because he must draw upon every resource of his knowledge and experience and out of these materials create a fabric which shall be coherent, consistent, and plausible. There need be no fear that he will carry his speculations too far, because, if he gets beyond the bounds of reason, the cold, hard facts of nature will quickly bring him back. On the other hand, when he comes to know that what he has imagined is quite possible and that he has created something in his mind that is actually duplicated in nature, he gains in self-confidence and therefore in mental power.

I have found beginners to be very diffident about hazarding an opinion as to why certain things are so. They seem afraid to give a reason, unless they remember to have seen one given in the text-book. But I encourage them to give every one, pos-

sible or impossible, which they can think of. Of course there are some wild guesses, but there is some good thinking too; and when several of them find that they have thought rightly, there is a distinct gain of power.

Someone has said that a miner can see no farther than the point of his pick. This is true of his physical sight; but it is his creative imagination which makes him keep on swinging his pick until his efforts are rewarded by the pure gold.

Physical geography has so many problems of varying degrees of difficulty that it is capable, when properly presented, of developing, improving, and refining the creative imagination, and thereby the powers of self-reliance, productive thinking, and sound judgment.

Self-reliance is probably the greatest power to be gained by laboratory work. The other powers are developed by it too, and much information is given, but the greatest gain and the one most characteristic of such work is the confidence in himself which the student develops rapidly when he can handle the tools of the science.

The same diffidence exists here that we find in the chemical and physical laboratories—the same fear of possible failure that makes us all hesitate to attempt something which we have not done before. But, if we can only be induced or even compelled to make the attempt, the exhilaration of increased confidence will repay many fold for the disagreeable sensations of the first plunge.

The ingenuity of the New England Yankee is proverbial; and his success in meeting conditions in every land and clime is largely due to his supreme confidence in himself. Call it conceit or self-sufficiency, if you will; but, nevertheless, this power has enabled him to adapt himself to his surroundings in every part of the earth, to do what any other man can do, and to do it just as well until he finds a way to do it a little better.

He lived in a land where nature imposed hard conditions, but at the same time a diversity of conditions of soil, and climate, of land and sea, and of mountain, river, and plain; and, if he was to live at all, it was by taxing every resource of mind and body to wring from nature the food and shelter and reasonable safety of life which every man must have. If he had been content to confine himself to the methods which he or his forefathers already knew, he would soon have perished from the

earth. But the land of New England was a veritable laboratory; and, when he had exhausted its possibilities, he went out and applied what he had learned to the more fertile fields of the west.

Now the physical geography laboratory can be made to do for the student what New England did for the Yankee. We can present to him there a variety of conditions which will tax his ingenuity to meet and we can graduate those conditions so as to develop his powers without discouraging him.

The most impressive thing to a teacher, when he first puts a class into the laboratory, is its helplessness. The pupils may be able to recite ever so glibly from the text-book; but, give them some contour maps, some small globes, or some specimens of rocks and minerals and let them study them for a few minutes and then ask them what they have learned. Then ask a few leading questions and see how much they *can* learn. Your surprise will be of a different kind. After a few days, give them something different, and you will find that some of the helplessness has disappeared. If you will keep this up for a year, you will find yourself asking fewer questions, and you will find the pupils going at their problems with the air of veterans. They will not all do it, and some of them may have to come back next year and try it over again. But, did you ever notice the superiority of a last year's "failure," so-called, over one of the normally bright pupils who is taking the subject for the first time? It may not be universal, but it is apparent enough in many cases to make you believe that your work on the "failure" was not all in vain, even if he didn't pass his examination.

Laboratory work in physical geography has a value peculiar to itself aside from that contained in the mere subject matter. It is capable of training the powers in a different way from chemistry, or physics, or biology, or manual training. It is not antagonistic to any of these, but claims a place *with* them in developing the powers. It requires a certain amount of manual skill, particularly in drawing, it draws upon the other sciences to answer many of the questions which arise, and then it adds something of its own which the others cannot give.

This may be said of physical geography as a whole, and not only of its laboratory work. It is distinctly a *science*, and as such is capable of developing and refining the powers of the mind as no amount of manual training can do. To place it

on a par with *any* number of hours of shop work and drawing, where no reading or study outside of school hours are required, is to rob it of its virtue as a pure science; and to attempt to substitute for it an equivalent of American history in a so-called "Scientific" course is absurd.

Can physical geography arouse any enthusiasm? Any study will arouse enthusiasm just in so far as the pupils can be made to feel that it touches them in their daily life and experience. So, if we can make them feel that physical geography deals with those things with which they are in daily contact, we can arouse an intense interest and create a desire on their part to know more of those things.

Most of them have very little idea, when they first come to the class, of what physical geography is "about," as the expression goes. But, if we can show them that it is about the very ground they walk on, about the air they breathe, about the food they eat, and about the thousand and one things that go to make up their physical environment, then we can look for a large development of enthusiasm.

They have not traveled widely, and it is difficult to get up much interest in what they have not seen; but, as a matter of fact they have seen more than they think they have. For example, it is hard to get them interested in the belted coastal plain of southern New Jersey—just a bit of land along the Atlantic coast, with some features which they must learn, but not particularly interesting if they do not happen to live there. If, however, we can show them that Cleveland is located upon a similar bit of land, that southeast of the city is the cuesta which they can see from the class room, that the building stands upon the inner lowland, that the divide is just beyond Akron, and that another cuesta rises gently toward Niagara Falls, then the New Jersey plain acquires a new interest and they are anxious to study it in order to understand the Cleveland plain.

Again, the Glacial Period seems a remote and intangible thing until we bring it home to Cleveland, and then it becomes a very real thing when we point out what it has done here.

So we might go on with numerous examples, but further illustration is not necessary to show that, if we will only bring these things home and make them real, physical geography is capable of creating a desire to know not only Cleveland and its vicinity but to know other parts of our own continent and other

continents and to know how and why the people who inhabit them live as they do.

Physical geography has been defined as the science that treats of the physical features of the earth which influence the manner in which man lives upon it. The last part of the definition, which shows the intimate human relation of the subject, is the strongest argument for continuing to include physical geography among high school studies.

In an address before the National Geographical Society, about a year ago, upon the moral and material aspects of geographical explorations. Gen. A. W. Greely said "The growth development, and ultimate limitation of nations are largely influenced by, if not entirely due to geographical environment. The location of great centers of agriculture and commerce, of special industries, mining and stock raising, is the outcome of careful exploration of the special economic resources on which their success depends. \* \* \*

"The work of geographical exploration has usually passed through three distinctive phases: First, commercial purposes; second, advancement of knowledge; third, scientific explorations. Prolific as have been the earlier stages, it is the last named which has been the most potent force in the development of America, especially in the past, and which is so rapidly changing Australia and Africa at the present time. All and any of these methods have been, it is believed, fully successful only so far as there have been conjoined therewith moral forces as adjuncts of physical efforts. \* \* \* The moral results are associated with the generous assimilation and liberal development of discovered regions, under conditions whereby the civilized world benefits in the aggregate, and primitive folk are raised higher in the scale of humanity. In such cases the natural resources of the country and the mental activities of the people are made to increasingly subserve the new regions involved and by reaction similarly improve the rest of the world. Intelligence, justice, temperance, tolerance, fair dealing, and educative methods along the higher moralities are essential qualities of the true explorer. Their practical and successful application is an important factor in the evolution from uncivilized materials of a modern state, so as to justify its admission to international comity."

Do not these splendid words of Gen. Greely, himself a noted geographer and a true explorer, bear eloquent testimony to the fact that geography has that quality of culture which tends to the improvement of mind, morals, and tastes, and to enlightenment and civilization?

### THE VALUE OF THE INDUCTIVE STUDY OF RELIEF FORMS IN FIELD WORK AND CONTOUR MAPS.\*

BY WILLIAM H. PLATZER.

*Poughkeepsie, New York.*

Suppose we limit the subject to the inductive study of relief only. This will make the discussion more specific. In doing this the thoughts that I will present have been gathered from my experience in the class room and field, as I claim no special knowledge of geology or pedagogy. I am glad Dr. Hopkins asked me to prepare this paper for it has brought clearly before my mind the points on which I need to ask questions of others. I hope to provoke such a comprehensive discussion that it will help me in the solution of some of my problems.

To one who has followed the syllabus of 1900 with a class it is evident that there were a great many facts to be taught that could never be more than mere facts to the student because of the limited time given to the course and the purely text-book method of procedure. All the matter presented may have had a definite enough place in our own minds, but if we were to stop to consider just how that knowledge came to be systematized most of us would find that it was not gained in the five months' study of this subject in a high school. I fear that some of my reviews at the end of the term were mere catechisms. A science teacher in one of the New Jersey high schools who had been placed on a committee to draft a syllabus of physical geography told me that he believed he would recommend that the subject be dropped from the high school course. He only thought of the subject as we taught it according to the old syllabus as a mere collection of facts about the earth and the physical sciences. The great trouble is that as students and teachers we failed to see in the brief glimpses of physics, chemistry, and biology, a gradual development of our earth or if we saw it we failed to find the means of unfolding that idea to others.

The average student who comes to us from the well taught graded school has such a conception of the relief forms of the earth that there is no necessity for us to attempt any inductive work in the study of the form itself. The pupil, however, has still to learn the processes by which such forms were at-

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\*Read at the meeting of the N. Y. State Teachers Association at New York City, Dec. 26 and 27, 1906.

tained. If the true scientific spirit is to be carried into our work in physical geography this should be done by the inductive method.

Here is our opportunity to make the best use of field work and contour maps. I prefer to have the first laboratory exercise in the field and do not think of using a contour map until considerable field work has been done, nor do I use a map where the material for the lesson can be obtained from the field.

Although it may seem more logical to take up the work on the atmosphere first, we have found it at Poughkeepsie a matter of convenience to begin with the land. This is because of the fine opportunity that we have to study the cycle of erosion there. We give most of the time allowed for field work to this feature and find that the observations on the atmosphere can best be made in the latter part of the school year.

Allow me to use an illustration the way we have studied the development of flood plains. A meadow just east of the city furnished our material. The value of the field for this purpose is increased by the fact that a small stream meanders through it. The class each time went to the field provided with small notebooks and a sheet of questions designed as a guide in the work. One of the first things that they were asked to do was to discover the origin of the material of which the plain is composed. They never found trouble in solving the problem after they had compared the soil with the material found in the various curves and other protected places along the stream course. There was always some boy in the class who had seen the meadow flooded in the spring time and who could locate some of the material left at that time.

In like manner by asking the pupils to determine what seemed to be the highest and driest part of the plain it was not difficult to bring out the idea of the development of the natural dikes. I found that to do this it was necessary to lead them through a series of reasoning on the variation of the transporting power of water. It also became evident that one could not rely altogether on a prearranged direction sheet for this purpose. It was easier for me to explain the transporting power of water in the field than in the class room.

The presence of curved marshes in the meadow furnished the material for the study of oxbow lakes and their disappearance.

Such other features as could be used were studied and the students were left to work out for themselves what would be the effect of the continual shifting of the meandering stream. This was followed by the text-book study of the valley of the Mississippi and the detailed study of the Donaldsonville topographic sheet.

The value of this plan of procedure over the purely text-book method was tested last fall in our work. On a written lesson which included many features of old stream courses the class was asked to explain the process of the formation of alluvial fans. This was one feature which we did not happen to find in the field and nearly the whole class failed on that question while all answered correctly the questions covering the work studied in the field.

In discussing diastrophism we have to content ourselves at Poughkeepsie by studying the folded strata exposed by the railroad cuts. When the idea of the original position of stratified rock has been fixed it seems possible for the student to get some idea of the changes which have resulted in the present positions. I have, however, found this the most difficult part of the field work.

In working out the idea of the life history of mountains I have made use of the Harper's Ferry and Natural Bridge topographic sheets. It is certainly necessary to spend some time in preparing a class for this kind of work. My class began by building profiles of an imaginary island and then a contour map of the island and locating a stream course on the island. They then constructed profiles of the natural dikes on the Donaldsonville sheet. I have found that with this amount of preparation the average student could begin to interpret contour maps as to elevations and depressions. In studying maps of mountainous sections I have the student give as much as he can of the origin of the ridges and depressions and always his conception of the appearance of the country in a previous stage of erosion. The section is also considered in its relation to man.

After the ability to use the contour map has been acquired I believe that the mere mechanical work with the map should cease. I have never required more than one profile map of a student and this for two reasons. First, this phase of the work develops into mere busy work. Second, unless the time is

largely spent on work which call for some amount of thought the main object of the laboratory work is lost.

My experience has demonstrated that the laboratory sections should be small and that all should be at work on the same map at the same time. By all working on a map of the same section all the members may get the benefit of the questions asked by both students and teacher. Of course cases do arise where students will depend too much upon other members, and one might wish that adjacent students were not at work upon the same maps.

The directions given to the student for the study of the map should not be much more than outlines and the teacher must be ready to lead discussions and ask questions as the work advances. As a result of a discussion started one day in our class one of the girls had the old and well fixed idea that "a volcano is a burning mountain," rooted out of her head by settling the fact that Mt. Shasta was a volcano long before that part of the cone which rises above 8,000 feet of elevation was formed.

Our work on contour maps included the study of coastal plains, lake plains, flood plains of rivers, plateaus and mountains. In nearly all cases maps have been selected so as to show the effects of erosion on these features.

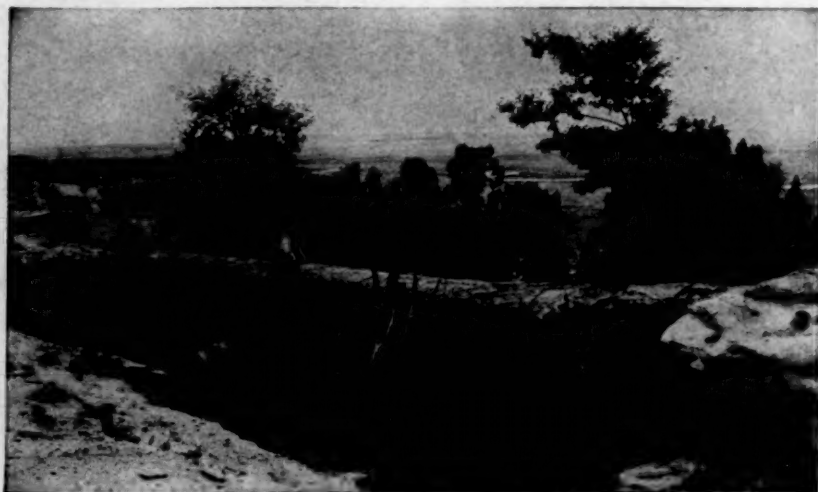
I cannot see why classes that can visit coastal plains or a sea-shore cannot work out inductively the formation of that class of plains and then by the aid of proper contour maps be led on to the development of the plateau. The combination of the field work at hand with the properly selected contour maps will make possible the inductive study of the life history of even our everlasting hills.

We have arranged our laboratory work to alternate with the class work whenever it is needed for inductive study. Of course sometimes this is not more than a demonstration. It is harder to arrange the field work so as to introduce topics with their related field work for the weather and other school plans have to be considered.

I believe too much effort cannot be made to keep the work of the field and laboratory from becoming mere mechanical drill. The less diligent students are apt to be satisfied with answers to questions of detail. For that reason the directions given the student should be as far as possible questions involving some amount of reasoning and not calling for direct answers.

A laboratory course in physical geography is a new departure in our educational system and it certainly deserves a distinct place. I tried to introduce a laboratory course in physical geography in the school where I was teaching two years before the present syllabus was written and succeeded in getting permission of the superintendent to have field work and map building. I believe even that concession was more than could have been obtained under a superintendent less interested in scientific work. A new course may be expected to have its imperfections and we have no doubt much to learn as to just what to give and how to present it. It does seem to me that some of the experiments suggested in the present syllabus are beyond the second year student. In fact I am sure that no one of our second year students could grasp all of them. Is it not true that the department's directions for the study of contour maps are in many cases too long for the time we have to give to them?

I believe that the introduction of laboratory work in physical geography is a step in the right direction by means of which we are going some time to give the student a splendid opportunity to develop scientific habits of thought. By the inductive study of the phenomena which he constantly sees, valuable information will be given. He will go into the physical sciences better prepared for scientific work and he will obtain a glimpse of the possibilities of matter and energy which he could not otherwise acquire outside of the college.



Petrified Log Bridge on Line of Santa Fe Railroad.

**THE BUREAU OF GEOGRAPHY OF THE CHICAGO PUBLIC SCHOOLS.**

BY JANE PERRY COOK,

*Chicago Normal School.*

Within the last few years much use has been made of illustrative material in the teaching of Geography. This has led to the collection of books, pictures, lantern slides, specimens of products of different countries, natural or manufactured, and to their arrangement into suitable and convenient form for use in schools. Chicago was one of the first cities to make such a systematic collection and to organize it in such wise that it could be drawn upon as needed by the various schools of the city.

This collection or museum is known as the Bureau of Geography and is now established in the new building of the Chicago Normal School. The bureau has become known outside the city in various ways, principally through a visit made to the Normal School last November by the Earth Science section of the Central Association of Science and Mathematics Teachers, at which time the rooms of the Bureau of Geography were opened for inspection.

Since this visit many letters of inquiry as to the management of this bureau have been addressed to the writer. To answer these letters in detail was impossible. The following account is therefore written in answer to these letters of inquiry as well as in the way of suggestion to teachers of geography.

The Bureau of Geography was organized by forty-four principals of the elementary schools of Chicago on May 25, 1901. This organization was due in large measure to the efforts of Mr. Richard Waterman. Each principal contributed the sum of ten dollars and many business firms in the city and elsewhere were asked to make contributions of material suitable for geographic illustration. Much of this material was given free of charge and a part of the money contributed by the principals was used to buy the proper cases in which the exhibits might be safely shipped to different parts of the city.

Finding after a time that the work of administering the Bureau was very heavy, the principals decided to give the collection into the keeping of the Board of Education, which assumed the management October 28, 1903. The following month the Bureau of

Geography was transferred to the Chicago Normal School, where it is under the direction of the Department of Geography.

The work of carrying on the Bureau is in the hands of a salaried curator appointed by the School Board. It is his duty to send out supplies on the written requisition of the principals of the elementary schools, to verify the contents of the boxes on their return, to collect material, to arrange such material in sets, to select from whatever sources he may suitable descriptive printed matter and pictures to illustrate these sets, and with the approval of the Geography Department to expend such sums as may be voted by the Board of Education for the maintenance of the Bureau.

Each collection sent out from the Normal School is packed in three or more stout pasteboard boxes, made for the purpose. The set of boxes is shipped in a strong wooden packing case. One of these smaller boxes contains pictures, the second holds selected magazine articles bearing on the subject or typewritten descriptions of the materials, and the third box, divided into compartments by pasteboard partitions, contains bottles showing specimens of the product studied in the different stages of its manufacture or preparation.

These collections may represent:

- (1) A country as a whole.
- (2) A part of a country.
- (3) One product of a country.

(1) In the case illustrating South America the boxes contain samples of as many products of that country as could be obtained, e. g., rubber, coffee, etc. The literature and pictures were chosen to give as true an idea of South America as possible. Again the collection may represent (2) a part of the country, as for example, Argentina. The boxes contain typical products of Argentina and the pictures chosen are such as to illustrate the typical industries and characteristic physical features of that state. Still again the boxes may illustrate (3) one product of a country, as for instance wheat. In this case the sample boxes contain specimens of different kinds of wheat as well as samples of the various stages in the preparation which the wheat berry undergoes in the process of flour making. The pictures and printed matter illustrate the various processes of flour manufacture, as well as showing the methods of wheat raising and harvesting which obtain in America, Argentina, Russia, or any other wheat growing country.

Following is a duplicate of the blank order slip used by the principals in getting their supplies from the Bureau of Geography. The numbers placed after each product indicates the number of duplicate sets:

**Requisition Blank.**

To the Curator,  
 Bureau of Geography, Date.....  
 Chicago Normal School.  
 Please book for the..... School  
 the collections indicated below.  
 .....Principal.....

Date .....

**List of Collections.**

**FOOD PRODUCTS OF VEGETABLE ORIGIN.**

Wheat (15)  
 Corn (12)  
 Rice (10)  
 Other Cereals (6)  
 Coconut (5)  
 Spices (4)  
 Coffee (8)  
 Tea (7)  
 Cocoa (5)  
 Sugar (10)

**FOOD PRODUCTS OF ANIMAL ORIGIN.**

Live Stock and Provisions (3)

**RAW MATERIALS OF VEGETABLE ORIGIN.**

Cotton (8)  
 Flax (7)  
 Hemp (2)  
 Ramie (1)  
 Manila Hemp (4)  
 Sisal Hemp (2)  
 Pine Needle (2)

**RAW MATERIALS OF ANIMAL ORIGIN.**

Wool (11)  
 Silk (10)  
 Mohair (3)  
 Sponge (3)  
 By-products of the packing houses (3)

**MINERAL PRODUCTS.**

Gold and Silver (7)  
 Lead (4)  
 Zinc (4)  
 Copper (5)  
 Asbestos (7)  
 Iron (5)  
 Coal (5)  
 Salt (7)  
 Petroleum (5)  
 Graphite (4)  
 Aluminum (3)

**GEOGRAPHICAL COLLECTIONS.**

Alaska (5)  
 Hawaii (4)  
 Philippines (6)  
 Cuba (5)  
 Porto Rico (4)  
 Argentina (4)  
 Egypt (3)  
 Japan (6)  
 New Zealand (3)  
 Haiti (4)  
 Italy (4)  
 India (3)  
 Mexico (5)  
 Spain (2)

**PRODUCTS OF THE FOREST.**

Cork (7)  
Wood (9)  
Yellow Pine (1)

**PRODUCTS OF MANUFACTURE.**

Leather (9)

**SOCIAL RELATIONS.**

Transportation (6)

**MISCELLANEOUS.**

Rubber (7)  
Fruit (3)  
Nuts (3)  
Paper (4)  
Rattan (1)  
Jute (1)  
Asphalt (4)  
Gypsum (4)  
Building Stone (4)

Numbers in parenthesis show the number of sets available.

**Suggestions for Ordering Collections.**

Principal. Please detach suggestions for ordering collections before returning requisition.

These collections are sent to each public school free of charge, if ordered by the principal.

In ordering, place before the name of each collection desired, the number of the school week in which you wish to have it delivered at your school.

The collections called for will be booked in advance as nearly as possible in order indicated, orders being filled only on alternating weeks, to allow a school to use one collection for two consecutive weeks, as requested by a number of principals.

Requisitions will be booked and filled according to the order of their receipt, and a list of the collections as booked will be returned to you.

Any school showing a tendency to be irregular in the return of the collection or returning the same deficient or in a damaged condition, will be deprived of the use of material.



In order that the system of classifying and arranging the sets of this bureau be made plain to those who are making collections of geographic materials the silk set is chosen for illustration and will be described in detail.

Box A holds the bottles containing the perishable part of the exhibit. The box is divided into compartments and into each is fitted snugly a wide mouthed glass bottle. Each bottle 4 inches high and  $1\frac{3}{4}$  inches in diameter, is marked with the number of the set and the number of the bottle. The silk sets, of which there are ten, number from 223 to 233. Of set 223 the bottles are marked 223:1, 223:2, etc. The contents of the bottles are best shown by the index or catalogue which accompanies each set.

## Catalogue of Silk Collection 223.

- 223:1. Eggs of the silkworm moth on mulberry leaves.
- 223:2. Silkworm 10 days old.
- 223:3. Silkworm 20 days old.
- 223:4. Silkworm 30 days old.
- 223:5. Chrysalis of the silkworm.
- 223:6. Silkworm moth.
- 223:7. Cocoon pierced by the escaping moth.
- 223:8. Cocoon as spun by the silkworm.
- 223:9. Cocoon with the floss removed, ready for reeling.
- 223:10. Pierced cocoons useless for reeling.
- 223:11. Cocoons after boiling with soap to remove gum.
- 223:12. Cocoons prepared for combing.
- 223:13. Raw silk.
- 223:14. Frisons: waste made in reeling.
- 223:15. Frisons after boiling in soap to remove gum.
- 223:16. Frisons ready for combing (see L 223:3).
- 223:17. Combed silk.
- 223:18. Roving (fine).
- 223:19. Roving (coarse).
- 223:20. Spun silk (fine).
- 223:21. Spun silk (coarse).
- 223:22. Spun silk (colored).
- 223:23. Silk thread.
- 223:24. Silk floss.
- 223:25. Raw silk from various countries.
- 223:26 to 223:30. Dress goods.
- 223:31 to 223:35. Pile fabrics.
- 223:35 to 223:42. Ribbons.

## Literature.

- L223:1. Silk, its origin, culture and manufacture.
- L223:2. The silkworm and its silk.
- L223:3. A short description of silk and silk manufacture.

## Pictures.

- P223:1. The silkworm moth.
- P223:2. Chinese feeding the silkworm.
- P223:3. The mulberry tree.
- P223:4. Gathering the silk cocoons.
- P223:5. Chinese reeling silk by hand.
- P223:6. Spinning silk in an American factory.

As the index shows, the materials sent out are of three kinds (a) literature descriptive of the products, (b) pictures, and (c) the product itself in various stages of its growth, preparation or manufacture. The descriptive literature is sometimes obtained from current publications. If it is possible to obtain enough copies of a publication containing a desired article, the pages containing the article are cut from the magazine and bound in manila covers. For this purpose publishers have often furnished a number of copies of a desired publication at greatly reduced rates. If it is impossible to obtain enough material in this way the article or certain parts of it is typewritten and mimeographed. Sometimes the descriptive matter is copied from commercial reports and encyclopedias of commerce not available to the average teacher. However obtained, the literature is always placed between covers of manila paper held in place by brass fasteners.

The pictures, which form a very important part of the sets, are variously obtained. They may be either magazine articles mounted on stiff cardboard or they may be taken from the very attractive booklets with which manufacturers advertise their wares. Often times the use of photographic negatives may be obtained from private individuals. Many valuable photographs have thus been obtained for the Chicago Bureau of Geography.

The collection of the material is a work of time and patience. Many firms and individuals are glad to make contributions when the matter is properly presented to them. It is very rarely that any charge is made for the material furnished. In many cases large contributions were made on condition that the expense of packing and the express or freight charges be paid by the Bureau of Geography. One large Chicago firm has offered to make twelve attractive exhibits of fur, provided that the Bureau pay for the time of the man doing the mounting and arranging of the sets. The offer was accepted and twelve sets of fur are soon to be added to the list of the Bureau.

Sometimes the interest of the Chicago agents for foreign firms has been aroused in the work and they have been instrumental in obtaining exhibits from their home countries. Even now one of the representatives of a large firm of chocolate manufacturers has arranged to have sent by his firm in Holland a large amount of material, to make up into sets to illustrate the cacao plant and the processes its fruit undergoes in the manufacture of chocolate and cocoa.

Through personal solicitation by the curator new sets of materials are constantly being added to the Bureau of Geography, thereby increasing its usefulness and efficiency. Each year a greater number of schools are making use of its materials and it is hoped by those interested that the number of schools that the Bureau serves will grow in just the proportion that the Bureau becomes more and more perfectly equipped.

**CALENDAR REFORMS AND METRIC REFORMS.**

BY RUFUS P. WILLIAMS.

There are people even now who believe the earth to be a flat plain. Astronomers of the past generation recall an Englishman, Parallax, who, challenging proof of the sphericity of our globe, made a heavy bet on his contention. Though he lost he was not convinced. We once talked by the hour with a man who held this same view, though he had fair intelligence on most subjects. Such freaks are relics of bygone ages who would have been very much at home prior to Columbus and Galileo. But they seem not far behind living opponents of metric reform. Every progressive scientific reform has its laggards and opponents, who think the old order is best. The ways of their grandfathers are good enough for them. They prefer the horse car, or "hayburner," to the trolley or automobile.

Metric reform is no exception to the rule. One of the most notable instances in history is the change of the Julian calendar to the Gregorian. The adoption of this latter by one nation after another, after violent opposition, furnishes so complete a parallel to the metric reform movement that we give it at some length. The story of how Julius Caesar in 45 B. C., following the computations of Sosigenes, the Alexandrian astronomer, decreed that the year should have  $365\frac{1}{4}$  days is familiar to all, as is the fact that Pope Gregory XIII in 1582 made Old Father Time move his clock ahead ten days. Two motives seem to have actuated Gregory. (1). The equinoxes were getting out of gear. Caesar's calendar made too many leap years, 407 in fact, since the great dictator issued his almanac, 12 more than the astronomers of Gregory figured ought to be, in order to have the vernal equinox fall on the same day as in 45 B. C. This made the equinox so much behind. It would continue to grow worse and in time the reckoning would be as bad as in Caesar's time when the spring kalens might fall in the autumnal period. Some date must be fixed and the leap years readjusted. (2). Being also a devout believer in Athenasianism whose tenets, as opposed to Arianism, had been forever fixed on the Christian world by the convention of Nicaea in 325 A. D., Gregory conceived of the idea of fastening the date of that great event upon posterity by making the vernal equinox fall on the exact day in which it fell in 325, viz., March 21. In this he was assisted by the Jesuite astronomer Clavius.

As the Nicaean convention was the second important religious act of Constantine the Great, the first and greater being the adoption, only 12 years before, of Christianity as the state religion of the Roman Empire, Gregory's calendar revision had a strong religious flavor, and, coming as it did, at the time when Protestantism was making headway, it met with violent opposition. There is here no intended parallelism to the case of the metric system and the English, except that one of the strong points of opposition to the metric formerly was its being the product of atheistic France in its revolutionary period. Such puerile criticism is little indulged in at present, for everybody knows the men employed to work out the metric reform were among the ablest mathematicians who ever lived. The parallel in the reform calendar and the reform measures consists in the slowness of adoption of each. The slogan of F. A. Halsey with which in one of his tirades against reform he closed every paragraph, was "In weights and measures we are irrevocably chained to the past." So said England and so said Germany about the calendar, and so it has been time without end by every opponent of every reform. Galileo, Columbus, Watt, Fulton, Morse, Field, and all reformers who have sought to benefit mankind join their eloquent testimony. Such opponents have been well characterized as only flies on the wheels of progress, whose insignificance will be seen when the reform has culminated.

It took Germany 118 years after the Papal Bull had been issued to break away from the old order. Denmark and Holland also waited the same number of years before requiring by law the revised calendar. For 170 years England clung to the Julian order, and Sweden a year longer. Caesar's almanac is still good enough for Russia and Greece, even after 325 years since the reform began. Yet does any one imagine that these countries will always go on at a variance with the rest of the world, making the double system of dating necessary for all correspondence? It may surprise most people that the Julian calendar is still in use in these United States; yet such is the case. The writer, taking a trip a few years ago through the Kentucky mountains, found it there among our "contemporary ancestors," who still continue to celebrate Christmas according to the English "old style," and this 150 years after the adoption of the "new style" by most of the English speaking people. To

be consistent Mesrs. Dale and Halsey should lose no time in declaring the Gregorian Calendar a failure, as well as a fallacy. But let those who think the progress of the metric system has been slow ponder well the adoption by the various states of Europe of our present calendar. By comparison, the International metric system has made very great speed. In little over a century its use is required in the custom houses of most of the civilized countries of the world, and is very largely used in every nation, while with the exception of England and our own country, the most progressive nations make its use compulsory. Again, let questioners recall that the Mohammedan nations are so far behind in their almanac that they have not even adopted the calendar that Julius Caesar promulgated forty-six years before Christ. The man who studies the history of any intellectual, moral or physical advance will find at every point these human obstructors who are either incapable or unwilling to see beyond their own immediate environment. But the opposition to the metric reform is mild indeed compared to that in England, for example, where riots accompanied the carrying into effect of the new dates where the feeling of the laboring class was the loss of thirteen days out of life, with attendant loss of wages. Now the opposition is a financial and an intellectual one. Yet who can believe that the calendar opponents were any more short-sighted than are the metric opponents of today? For less of a dictator than Caesar it would have been impossible to bring order out of the chaos into which the calendar had fallen. With a man less powerful than the Pope, the Gregorian reform would not have been, and we still might be in the same chaotic state in reckoning time, as we now are in weights and measures.

For an example of the persistence of custom one has but to consider the history of Christianity from its humble beginnings 2000 years ago. Let one study the evolution of constitutional governments, noting the slowness of progress. Take coinage and printing. The first coins are said to have been stamped about 700 B. C. One is surprised that stamping on paper, or printing, did not follow for nearly 2000 years. Dr. Mendenhall once said that a volume a foot thick could be written on the persistence of custom. The educated mind moves slow; vastly slower the untrained.

Measured by almost any standard the progress of the metric system has not been slow. It is now but little over a century since it was worked out and first introduced into France. But Napoleon went back to the old order, and France, the first nation to adopt it permanently has had it in operation only 67 years, or since 1840, when it was finally made compulsory. Since that time it has spread with varying rapidity over the civilized world. In Germany its compulsory use dates from 1872, 35 years ago.

The following statement from a textile manufacturer shows the rapidity of its growth:

"As a reply to those who persist in asserting that on the Continent, where the Metric System is compulsory, the old weights and measures are still to any appreciable extent in use. I may say that, on a recent visit to Germany, I had an opportunity of enquiring, in manufacturing circles, into the truth of these allegations. I was everywhere told that they were devoid of all foundation and that the present generation did not even understand the old weights and measures except in so far as they learnt such in any particular trade they engaged in and which custom had preserved just as it preserved old terms, which had no meaning for others outside that trade. Such instances one can find by the hundred in this country, alongside our own weights and measures.

The conversation turning on land, I made use of the old German measurement, 'Morgen,' almost the equivalent of our 'Acre.' I asked how much a 'Morgen' was and neither of my companions, both educated young Germans, aged about 29 and 31, could tell me. 'We do not talk about "Morgen,"' they replied. 'We say, "Quadratmeters."' Our business conversation was on textiles and no other German measurement was once used except meters and centimeters. To find any other weights and measures in shops or business houses but the metric, you would have to travel into some very outlandish places."

That in so short a time it should have superseded all other systems as *the system* of scientists, and in the main as the system for governments, as well as very largely in popular usage, illustrates in a striking manner the law of survival of the fittest. Its progress has been vastly more rapid than the march of Gregory's calendar. How can one contemplate these two reforms and not believe in the ultimate triumph of the metric system? If opponents will take a fair view they will see that the

utmost they can do is to hinder for a brief time the coming of this reform; to make young students waste a few more years of life over doggerel weights and measures; to try to block the course of American commerce with foreign nations; to attempt to hinder the inevitable law that the best will finally survive. At life's end they will look back on having accomplished the above brilliant achievements.

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### THE PHYSICS CLUB IN A NORMAL SCHOOL.

By L. A. ROBINSON,

*Oregon State Normal School, Monmouth, Oregon.*

The great need of normal school students, as indeed of all students, is constructive thinking. Whatever brings out the pupil's originality and exercises his real genius in what counts towards making him a power in the world. This power rightly directed, being the purpose of education, is of utmost importance in school work. This furnishes the reason for teachers being required to know so much more than the mere facts that they teach. Perhaps it is equally true in other vocations that men to make noted success must know much more than the facts with which they deal directly. Among other things it is recognized that a knowledge of elementary physics is fundamental to every educated person. This being true it is especially necessary in the education of the teacher. Then the question is, how shall the subject obtain its maximum value in the schools? We are not yet satisfied with our teaching of physics. And while the outlook in this direction is more promising than ever before, still the conglomeration of laboratory exercises, lecture table experiments, and class instruction that we teachers force upon our students, often simply mystify them without giving a clear conception of any one phenomenon in its entire relations. It is in the interest of wider and better thinking that we have organized the Physics Club.

The Physics Club of the Oregon State Normal School has been in operation over three years with a steady interest. The membership each year has been about 50, with an average attendance at the meetings of about 35. The meetings are held on Thursday evening of each week from 6:30 to 7:30. Part of the time the meetings are held only once in two weeks. The programs are

varied, but are given nearly entirely by the students. Sometimes a discussion on the work of some noted physicist is given, very often an experiment is performed and explained before the club. Frequently the experiments are done with apparatus improvised and constructed by the student. Originality and novelty are encouraged. It is worthy of remark that in this way many pieces of useful apparatus have been added to our laboratory; and sometimes by unsuspected genius in some student.

The practical value of the Club to our students may be generalized under these heads:

(1) They learn self-reliance in reaching conclusions and in stating them before an audience.

(2) They cultivate their genius in constructing and manipulating apparatus.

(3) They get many illustrations of principles that on account of lack of time have to be omitted from the regular class instruction. They also show the instructor his weak points in teaching and thus indicate the way for better instruction. The expression of the pupil is a better gauge for the reforms of teaching than any number of theories.

It is not expected that a voluntary club will be equally adapted to all schools, but the interest in physics has been much promoted by the Club here, and I believe that some corresponding exercise is practicable in every secondary school. The value of one experiment studied in detail and explained before an audience is worth as much to the performing student as three experiments worked out in the laboratory and merely written down on paper. Expression is a good thing; action is a good thing; but expression and action together is the ultimate of success. It is this higher success that we especially seek, and, as I believe, may in large part realize through some such agent as the Physics Club in our schools.

**A METHOD OF ASSIGNING LABORATORY WORK.**

By J. HARRY CLO,

*Instructor in Physics, State College of Washington.*

Almost all teachers of laboratory physics and many teachers of other laboratory sciences, at some time or other, find inconvenience and dissatisfaction in assigning experiments at the beginning of a period. This is especially true of work in elementary physics, where owing to largeness of classes or scarcity of apparatus, it involves the loss of valuable time or causes much confusion if the pupil is allowed to choose his experiment for the period. In the latter case, the pupil has difficulty in securing apparatus and often finds it in use; or, if he performs a second experiment during the period, he must first determine what apparatus is not in use. In the former case, unless the pupils all work on the same experiment at the same time, the teacher must arrange their work in the proper order. If each pupil is assigned one experiment and one completes his and is to perform another, the teacher must suspend operations to see what apparatus is available, thereby losing time. The problem becomes more complicated where one teacher has more than one section of the same class, working at consecutive periods and using the same apparatus. This condition has brought about the adoption of the following system by which the teacher may assign a whole day's work and at the end of the day, know just what each pupil has done.

Suppose that there are three sections of a laboratory class, of about twenty-five pupils each, using from two to five sets of apparatus for each experiment, and that the teacher desires to assign work for the day to these three classes. Some experiments are to be done by one pupil, some by two, and some by three, etc., and a pupil is allowed to work on as many as three experiments in a period. Some apparatus is not to be moved, but most of it is to be taken from a case or table by the pupil and returned by him. The teacher must attend to the following requirements: When the pupil enters the laboratory he must know what and how many experiments he is to perform, whether he works alone or with one or two companions, whether or not he is abreast of the class, etc. His manual will tell him what apparatus he needs, but he must be told where to find it, and while he has charge of it no other pupil should attempt to use it or any part of it. After

he completes the work of an experiment, he should know whether or not the apparatus required for his next experiment is in use. If it is, he must appeal to the teacher or find another set. In the former case the teacher must be able to find the other set without delay. After completing any experiment he should be able to indicate the fact without disturbing the teacher and also indicate to the class that he is through with the apparatus he has used.

An attempt is made to meet all of these requirements in the following system of cards and tags. Two boards are placed in the laboratory, one containing two hooks for each member of the class and the other containing two hooks for each set of apparatus left at the disposal of the class at any one time. It is convenient to have one of each pair of hooks under the other. Each pupil is given a number and if possible the numbers of each section are consecutive. These numbers are written in red ink or some characteristic way on small cardboard tags, at least one tag for each experiment pupil may be able to perform in one period. These tags are hung from upper hooks of the board provided for that purpose. If the pupils work in fixed pairs, the numbers of both pupils are placed on a tag, the smaller number first to avoid confusion. If each pupil is to have three individual tags on the upper hook and one partnership tag on the lower hook he can tell at a glance whether his work is to be individual or partnership or both. To indicate the exact order in which the pupil is to perform the experiments, his tags are numbered in series and he uses them in that order. This is not generally necessary. On each upper hook of the other board hangs a card with the number of an experiment. If there are five sets of apparatus for experiment No. 12, there are five cards labeled "12." These cards may differ according to some characteristic of the experiment. They may be large enough to contain a sentence. They may show where the apparatus is to be found. For instance, card 5-6-3 may indicate experiment No. 5, apparatus at table 6 or in drawer or case 6, to be performed on table No. 3. They should be arranged in some definite order, say from left to right, so that the pupil may know where to look for his experiment and may know in what order to perform them if his tags do not contain serial numbers.

At the beginning of the course it is often desirable to have the pupils work individually and to allow them to choose their ex-

periments, if sufficient apparatus is at hand. If this is to be done, the pupil takes his individual number from the board, steps to the board having the experiment cards and covers the number of the experiment that he desires to perform. In case this has been previously covered, he covers the next one and then takes charge of the apparatus. After taking the date for the experiment, he removes his tag from the experiment number and hangs it on the hook immediately below this number. If the period expires before he has completed his experiment, he hangs his tag below with the number inward. In no case is he to leave an experiment number covered by his tag at the end of a period. The instructor can now check off the experiment as performed, or after all the sections have used the board, he may cover the experiment number with the tag that was turned face inward, thereby reserving a set of apparatus for the pupil who did not complete his experiment.

The teacher may assign work by hanging the pupil numbers on the experiment cards exactly as the pupil would, except that he may cover one tag with another. If there are three sections he must assign them work, i. e., hang on tags, in reverse order, the last of the day first. Suppose experiments No. 9 and 10 are to be done by pupil No. 3. The teacher covers cards 9 and 10 with tags No. 3. The tag on 9 may not be covered by another tag representing a pupil in the same section, but the one on 10 may be covered by tag No. 6, on the assumption that pupil No. 6 can finish experiment 10 while pupil 3 completes experiment 9. If this does not occur, pupil No. 3 may be allowed to shift his tag to any uncovered No. 10, or use another tag, or the teacher may shift the tag to any No. 10 that is covered by a pupil number in the same section if that pupil has an exposed tag to the left of the experiment card in question, i. e., is working on a preceding experiment. If the pupils are to do an experiment in pairs or in threes, the double or triple numbers can be used in the same way as the single numbers, but if the pupil changes associates and no fixed partnerships exist, any number of single tags may be hung on an experiment card. In that case, however, it is necessary to have some mark on the card that will indicate that more than one pupil is to work at the experiment. The pupil whose number is uppermost will then hunt his associates for that experiment.

After all the pupils of the third section have been assigned work, those of the second section may be assigned by hanging the tags of the pupils on the same experiments, and likewise with the first section. Hence at the beginning of the day's work, if each pupil is expected to perform two experiments per day, each experiment card will be covered by from three to six tags. At the end of each period care must be taken to have each pupil remove his tags from the experiment cards, and the instructor must remove those of the absent pupils, for the following section cannot use the apparatus whose number is left covered. After the day's work is over the teacher can take the tags from the lower hooks, check off the experiments as completed or return those indicating unfinished work to the upper hook, and assign new experiments, changing from single to double tags or vice versa, at will. If at any time apparatus can not be found, it may be seen from the tags what each pupil has done and is doing. If a pupil desires to perform an experiment aside from those assigned him, a glance at the board will indicate whether or not the apparatus is available.

This system has been used by the writer in comparison with other methods, some in which the experiment number was used to cover the pupil number, and others in which the pupil was given the card and allowed to keep it until the end of the period. but in each case it was found to give better satisfaction. Although seeming to be rather complex, it will be found that the teacher does the difficult part and that the pupil's part is simple. For one section only it is very simple, and in all cases it has the advantage of being easily adapted to all conditions.

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#### APPARATUS FOR DIP-NEEDLE DEMONSTRATION.

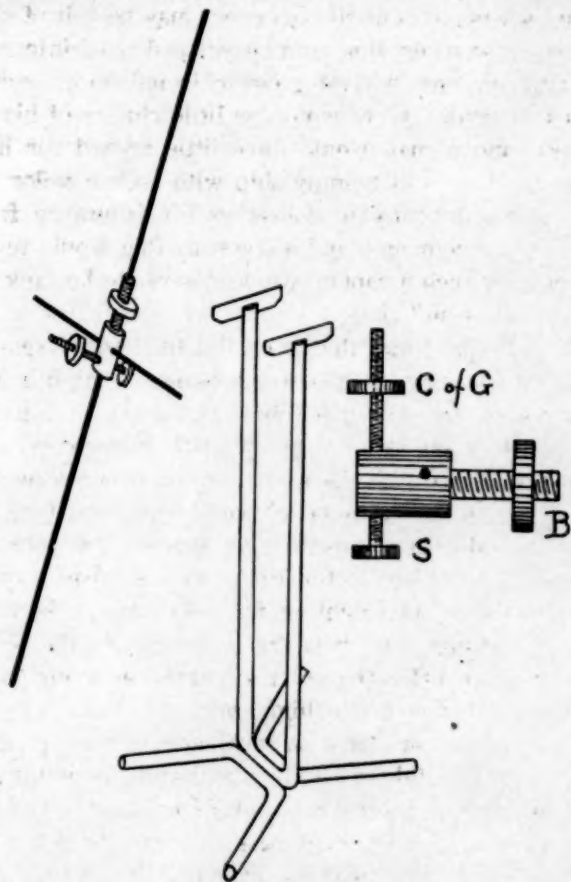
BY WILLARD R. PYLE,

*Morris High School, N. Y. City.*

In preparing for a dip-needle demonstration it usually takes considerable time and patience after balancing the knitting needle to make the further adjustments needed for great sensibility. This piece of apparatus reduces the difficulty almost to nothing.

The support is of  $\frac{1}{4}$  inch brass rod, and it stands  $6\frac{1}{2}$  inches high. Pieces of  $\frac{1}{32}$  inch sheet brass are sweated into slits at the top, the upper edges of the pieces of brass having first been

taken down to perfect smoothness on an oil stone. The distance between these supporting edges is  $1\frac{3}{8}$  inches. The needle-holder is  $\frac{5}{16}$  inch in diameter, and has a total length of  $\frac{7}{8}$  inches. The axis is made of a short piece of No. 16 knitting needle, sweated into a hole bored slightly above the one through which the unmagnetized needle passes. (This axis should always be



vaselined to prevent rust when the apparatus is put away.) S is a set-screw, B is a nut for balancing the needle, while C of G is used to raise the center of gravity as close to the axis as may be required for any desired degree of sensibility. Usually a slight adjustment of B is necessary after moving C of G. With a little practice the needle can be inserted into the holder, adjusted to great sensibility on the support, and finally magnetized in less than two minutes.

## WHITHERWARD IN CHEMISTRY?\*

BY H. F. SHELDON,

*Principal Armijo Union High School, California.*

'Tis indeed a careless mariner, who, in his wearisome journey across the trackless seas, with its treacherous currents and its veering winds, neglects to watch his log and take his reckoning. Experience from many and many a trip across the same water may be his; his traveling companions may have just as much empirical knowledge as himself; his cabin may be full of charts, atlases, treatises on navigation, and encyclopedias of information on winds, currents and general geographic influences—with all these invaluable guides, there would be little chance of his making safe port, and a man would have little regard for life or pocketbook who would knowingly ship with such a sailor. His heirs would have difficulty in collecting life insurance from a non-suicide-paying company, and a company that would reinsure a vessel piloted by such a captain would deserve to be ranked far below even the "six-bit" class.

It is a sign of the times that even the smallest of sea-going vessels now finds it necessary to carry a compass, and it is indeed only the smallest and most insignificant boat that has not also a sextant in its equipment. The greatest precautions, coupled with the most careful observations, are deemed necessary whenever life is in the keeping of one of our mariners. We realize more keenly the estimation by men of the value of a human life since the late example in our neighboring county of nearly three score men fighting for over two weeks to save an entombed workman, and it is the realization of the priceless trust that is his that makes the sailor so careful as to his position, direction and speed when on the high seas.

If a mature life is considered so invaluable, what price can be put upon that of a child with its wonderful possibilities just opening before it? It is trite to speak of this to a company of thinking teachers, yet its triteness shows its importance. Is it not true that we teach with too little regard as to just where we are in our work, as to the direction we are heading and as to the speed with which we are sailing? The keynote of our meetings is "Progression," and seldom do we hear the call to take soundings. Am I not just when I say that ninety per cent of our discussions are as to how we can strengthen our work in

\*Read before the Pacific Coast Association of Chemistry and Physics Teachers, Dec. 1906.

this or that line and that but a small part of the remaining ten per cent is devoted to thoughtful discussions as to the effect upon our pupils of this wonderful strengthening? It all reminds me of the man who taught his calf to go without food. The only difficulty was that the contrary brute up and died just as he was ready to demonstrate the success of his experiment. We have accomplished wonderful results in the teaching of chemistry, so at least I judge by the papers that I have heard read, but are our pupils thriving under our process of feeding? Whitherward are we tending? Let us stop for a few minutes to take observations, and then if necessary retrace our steps a little, even if it does hurt our pride to hinder this wonderful progression of ours.

What are our aims as chemistry teachers? To answer this question. I can not do better than quote freely from three admirable papers written by members of our Association.

Milo S. Baker,<sup>1</sup> of the Lowell High, San Francisco, in his outline states the aims as follows:

First term.

(a) To explain chemical facts the pupil has already acquired.

(b) To acquire a knowledge of the fundamental facts in chemistry through a study of the most familiar substances.

(c) To strive to inculcate the habits.

1. Of neatness and cleanliness.
2. Of recording observations carefully and fully.
3. Of distinguishing between fact and fancy.
4. Of forming judgments justified by the known facts.
5. Of suspending final judgment until all the facts are known.
6. Of verifying conjectures by further experiments.

Second term.

(a) Explanation in terms of molecular, atomic, and ionic theories of facts gained during first and second terms.

(b) Study of as many metals, non-metals, and compounds, not studied in the first term, as time will permit.

(c) Continued endeavor to fix correct habits.

Roy M. Fryer of the Sacramento High School under the head of "Advantages gained in the study of chemistry" sets forth the aims as follows:

(1) It trains observation in general and teaches one to draw correct individual ideas from observations made.

<sup>1</sup>School Science and Mathematics, April, 1906, pp. 273-283.

(2) It gives us much useful information about natural components of the universe and the principles of manufacture and properties of artificial products.

Summed up and considerably abbreviated, the aims of chemistry teaching are:

- (1) To teach certain chemical facts.
- (2) To make practical application of these facts.
- (3) To fix correct habits.

It would be foolish for me to quarrel with these gentlemen on the question of these aims. They are not only fair statements of the standards adopted by the teachers of chemistry as those towards which we should work, but they are also very high standards. My question is not as to whether or not we are advancing—of that there can be no question—it is only that I ask “What depth have we beneath us?” and “Whitherward?”

The questions were forced home to me in rather an emphatic manner by the evidences of a growing distaste for chemistry by the pupils of my own classes. It was not a case of one pupil or of one class, neither was it a case of a disinclination for work on the part of lazy pupils—the complaint came from those who had shown a capacity for both work and for taking pains in other lines. In two subjects in chemistry was the weakness most evident—in the study of theory and in the carrying out of quantitative work—but in the ordinary routine of experimenting I found that my pupils were falling far short of the inculcation of “habits distinguishing between fact and fancy and of forming judgments justified by the known facts.” Convinced that I had made mistakes in the outlining of the course of experiments as well as in the presentation of the subject, I began to look around me for suggestions as to how I could bring my work down to the level of my pupils. My dismay can be well imagined when I found that, in theory at least, my fellow teachers were planning, and apparently carrying out, courses in the subject far above any that I had ever attempted. For every one quantitative experiment that we undertook they had two, three or four, while our theoretical work was to theirs as division is to square root. Little comfort was gained by writing to chemistry teachers. This definite question was sent to about half a dozen wide-awake teachers: “Do the pupils enjoy the study of chemistry as former pupils did? Why?” These are some of the answers: “All the pupils with whom I have had any ac-

quaintance do." "I do not know." "Yes, more, because they know they are being directed, not drifting, whereas the phenomena are common to the two cases giving interest content."

I need not quote further. But one conclusion was possible. The failure was not in the amount of matter presented, for I had always advocated moderation in the presentation of all the subjects with which the pupils find difficulty, consequently the bitter fact was forced home that it was simply in my presentation of it. That conclusion still remains with me, but modified largely by further light upon the matter.

One of my former pupils home from the University of California for his holidays, in answer to my questioning as to his work, spoke of the difficulty the major part of the Freshman class found in chemistry. A reader in the subject had told him that at least thirty or thirty-five per cent of the pupils who had already taken the final examination in sections preceding his had failed. The instructor had announced the course at the beginning of the term in words similar to these: "Count four persons around you. Unless this is an exceptional class, one out of every four counted is going to fail." My pupils were without doubt represented among these failures, but "there were evidently others." Only the brightest of our graduates are encouraged to take up university work, and yet less than twenty-five per cent of these are unable to master Freshman work in chemistry.

Is there not something wrong? The young man with whom I had been talking was very mature in thought and judgment, so I began to make inquiries further. "Did you find much difficulty in theory?" I asked first. "No, the difficulty was not with the ionic theory," he laughingly replied, "neither was it in the mathematics of the subject"—(I had emphasized both subjects with this class)—"it is simply that we do not remember *all* of the facts told us." Lack of thoroughness is evidently the cause of the failure of most of our graduates in their University work. Our pupils may have been taught to "distinguish between fact and fancy" to the queen's taste and their "suspension of judgment" may have been so thoroughly developed that it did not come down for use in their Freshman year in college—however that may have been, it is evident that there is lack of both thoroughness and thought in the output from our science courses.

Among the questions sent out to the high school teachers was this one: Are our chemistry graduates stronger today in the subject than they were five years ago? How would you have answered the question if I had addressed it to you? Would it not have been that of practically every one from whom an answer was received, i. e., "Yes, the present day graduates are stronger." Another question asked was: Are our graduates today better prepared, in chemistry, for the University than former graduates? This, as the former question, elicited the practically uniform and expected reply: "Yes, they are better prepared." One very conservative teacher wrote after this question: "I would consider them better, as I think more thorough work is now done and laboratory methods have greatly improved. I would rather hear the opinion of a university instructor upon this point." I had already received a communication from one of the University instructors upon this same point. Knowing his extreme conservatism as well as his kindly spirit towards high school work, I feel justified in quoting very largely from his letter. It contains rich food for thought. He says: "I very seriously doubt whether any material advance has occurred for a good many years in the methods of chemistry teaching. Judging from the results of six years of Freshman work at the university I cannot see that students entering now bring with them any better knowledge or understanding of chemistry than did their predecessors—and carrying my mind still farther back to the prehistoric days when I entered the University from the 'Boys' High School' of San Francisco, I cannot believe that the boy of today is a whit wiser in a chemical way than was the boy of a quarter of a century ago. In fact, were I to make any distinction (and this may be a matter of personal prejudice) I should declare in favor of the ancient boy. Of course the new boy has heard of new theories—theories that had no existence in the olden days—but the older theories were good enough in their day and the old boys understood facts as then explained fully as well, if not better, than the new boys.

"I do not know that there are any reasons for this condition. Possibly the new boy has too many other interests and can devote less time to chemistry; possibly the tendency exists to glorify physics too much as an 'exact' science and give to the student the idea that chemistry is an 'inexact' one and that any

old thing will do; possibly it is due to the irrational and extravagant development of the laboratory method in which a raw, green student is expected to discover and digest in a term, facts and laws that have taken the leading chemists of the world a century to discover and understand."

This very kindly arraignment of the "new boy" and incidentally of the "new boy's teacher," is directly at variance with the opinions of all the high school teachers heard from. Is it not time to stop and consider "Whitherward?"

In what ways are our methods different from those in vogue fifteen years ago? At that time the laboratory method was just coming into general use, many of the experiments being spectacular (and consequently highly interesting) rather than one little part of a complex whole supposed in its entirety to exemplify some theory. Theories were read as theories and little attempt was made to more than elucidate them. The study was deductive rather than inductive. That this is not considered "the thing" now is shown by the tone of the papers presented in every meeting of the Association. I quote from a paper presented in Los Angeles by one of our members on the "Formal Discipline of Instruction in Science," it being, I think, as fair a presentation of the attitude of mind of our teachers in regard to chemistry teaching as I can find. "The chief object of education in science is no longer the acquisition of facts, but training in the *scientific* or *inductive* method, the method by which mankind has come into possession of the facts, and has discovered their significance," and further, "The problems of life require to be solved inductively." It is true that this author says later in his paper, "At every step in this subject (physics) deduction supplements induction." That alters the question not a whit. It seems quite evident that the great difference between the work to-day and that of ten or fifteen years ago lies in the fact that especial emphasis is now placed on the inductive study of the subject as opposed to the deductive tendencies of the newer but rapidly developing laboratory science. If this statement be true, and I personally feel that there can be no question about it, then the fact that there is some real doubt as to our present day pupils being stronger than those of a decade ago shows that there is at least a possibility that our inductive methods have not the power of developing strength that we fondly imagined they had.

That the aims of our modern teachers of chemistry are not heartily in accord with other educators of authority, besides the one I have quoted, is shown by the following extract from a paper

by Dr. John F. Woodhull of Teachers' College, Columbia University. He says: "Men who have spent several years passing through this sort of experience (comprehending by continued repetition) in the study of chemistry and who have arrived at pretty clear ideas themselves, undertake to teach these ideas full-fledged to beginners. Thoroughness and accuracy are their aim. To go slow and cut a wide swath is their method. They are champions of the *intensive* as against the *extensive* method. They demand of the beginners definiteness, sureness and completeness of knowledge and they attempt to make a few quantitative experiments furnish what time and extended experience alone can supply. \* \* \* I do not object to intensive work nor to quantitative experiments. We must admit that they are the cream of the whole matter, and yet insist that, like the nutritive part of food, they must be mixed with a large bolus if digestion is to proceed. Certainly the notion that an experiment is a vehicle for training in accuracy primarily, is a very harmful superstition. \* \* \* As for the main results to be sought I should say that, if a pupil understands his text-book in chemistry as well as the average pupil understands his history, we ought to be satisfied." Does that sound like "The aims in teaching chemistry are the cultivation of exact observation, correct interpretation of observed facts and the discovery of their relations, and rational explanation of facts and their causes by referring them to their real causes?"

Let us face this question together, admitting as we do so that *possibly* the University men were right. Is the close induction outlined in the above (our "creed" in chemistry) possible for young boys and girls of the age of our ordinary pupils? Personally I think it impossible, and in our striving to hold them to it, we have taken much real university work into the high school, thus crowding all but the strongest pupils out of the work, and at the same time forcing the subject into the category of, I believe in the ordinary case, heartily detested studies. My experience in three high schools of the state is that very few pupils elect the course in chemistry. Why is this so?

The texts are not wholly blameless in the matter. Answering the popular demand authors have elaborated dictionaries of facts in chemistry and sent them forth as texts. Compare one of our modern texts with one of Tyndall's works. Which would you take up during the spare half hour? How many of the innumerable facts given in the later book would you remember? To quote again from the letter which I received from the University of California instructor (Edward Booth): "Too often the

high school text-book is little more than a college text-book condensed to such an extent that all the interesting facts are omitted and it has become but slightly more interesting than a dictionary. I can conceive of a text-book that might omit about 3,147 facts and yet give a student a livelier interest in, and a better conception of chemistry than the condensed chemical encyclopedias now used as text-books." It is considered good form for high school teachers to rail at the text-books and to that extent this incomplete paper has complied with the polite usages in paper writing. The fault, however, with the texts has for its root faults in the teaching of the subject, for the demand has been but answered in the supply. It is not considered good pedagogy to teach history from compendiums of facts about history—why should it be considered good teaching to use something similar to a compendium in teaching chemistry? Let us in justice to our pupils, the subject, the university, and ourselves, placing in the hands of the pupils something which will be read for what is in it, of live interest, rather than studied to find some statement to fit in with some point in an experiment.

The following are the conclusions at which I have arrived after studying the matter:

1. We are expecting too much from our pupils in chemistry.
2. We are not making the study of chemistry interesting enough, largely because we are not making it alive enough.
3. Our laboratory work is too mechanical, because it is too often meaningless to the pupil. Less laboratory work with more discussion of what is done would bring about better results.
4. Our laboratory work is too largely quantitative. Very little quantitative work should be given in the high school.
5. Our texts should copy more the style of the masters of science who have written scientific treatises. They should attempt to cover less ground, but what is given should be treated in more of a connected manner. Practical everyday matters should receive much more attention, relatively, and the industrial side be much more strongly emphasized.

Having prepared the material for this paper in a spirit of criticism of my own work, I hope that the teachers will take what I have said with this idea in mind. Difficulties which I have spoken of as being general are perhaps only local, and it would not be at all surprising if the lack of interest which I have felt growing regarding chemistry has its rise in my own laboratory. You must judge of the question for yourselves. I questioned as to my own work "Whitherward?" and in answer to the request from your president, I have given you the benefit of it.

**EXPERIMENTS FOR DETECTING FOOD ADULTERANTS.**

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**Experiment 1. To Test Milk.****A. To Test for Formaldehyde.<sup>2</sup>**

Place in a test tube 5 or 10 cc of milk and add an equal quantity of strong hydrochloric acid and a piece of iron alum about the size of a pin head. Mix the liquids with a gentle rotary motion. Place the tube in a bottle filled with boiling water and allow to stand for five minutes. A purplish color of the mixture shows the presence of formaldehyde.

When the HCl is first added to the milk before the addition of the alum a pinkish tinge suggests the presence of a coal tar color.

**B. To Test Milk for Borax or Boric Acid.**

Dissolve 1 g of alum in 50 cc of water and add 25 cc of milk. Shake vigorously and filter. Pour about 5 cc of the filtrate into a test tube and add five drops of hydrochloric acid. Dip a piece of turmeric paper into this solution and hold over the flame until dry. Place a drop of ammonia on the paper. A cherry red color before adding the ammonia and a dark green or greenish black afterwards show the presence of borax or boric acid. The latter test is the better as an excess of HCl may cause the dry paper to become brownish red. (Turmeric paper may be made by dipping filter paper into a solution of turmeric powder in alcohol.)

**Experiment 2. To Test Butter and Similar Fats.****A. To Distinguish between Oleomargarine, Rejuvenated Butter and Fresh Butter.**

For the first test melt a small piece of the sample in a crucible cover, stirring with a splint of wood. Oleomargarine and rejuvenated butter sputter and boil noisily without producing foam, while real butter boils quietly and produces a large amount of foam.

For a second test fill a test tube half full of sweet milk with the cream thoroughly mixed, or skimmed milk may be used. Heat and add a teaspoonful of the sample to be tested. Stir with a wooden splint till the fat is melted. Cool the test tube by allow-

<sup>1</sup>For a more complete discussion of the methods of detecting food adulterants see Bulletin No. 100, Bureau of Chemistry, U. S. Dept. of Agriculture, entitled "Some Forms of Food Adulterations and Simple Methods for Their Detection." Price, 10 cents. This may be obtained by addressing Supt. of Documents, Washington, D. C.

<sup>2</sup>Reprints of this article may be had from this Journal at the rate of 30 cents per dozen, postage paid.

<sup>3</sup>In making these various tests for the first time, a little of the adulterant to be tested for should be added to the food being examined, so that the pupils may see what results follow when the adulterant is present. Then subsequent tests may be made with the foods as obtained.

ing the water from the faucet to run against the outside and stir the mixture till the fat hardens. If the sample is oleomargarine it will harden in one mass and may be lifted out on the splint of wood. If it is butter, either fresh or rejuvenated, it solidifies in granules scattered all through the milk in small particles. From these two tests explain how you can distinguish between the three kinds of fat.

B. To Test Butter for Borax or Boric Acid.

Place a small piece of butter in a test tube and half fill with water. Immerse the tube in a bottle containing hot water till the butter melts. Stir the contents and cool the test tube with water till the butter hardens; then remove the rod with the butter adhering to it. Filter the liquid. Test the filtrate as directed for milk in Experiment 1 B.

Experiment 3. To Test Meat Products, such as Sausage and Chopped Meat.

A. To Test for Borax or Boric Acid.

The sample should first be macerated with a little water and then strained through a white cotton cloth. The test may then be applied as directed for milk (E experiment 1, B.) or the liquid may first be clarified by cooling and filtering.

B. To Test for Sulphides.

Macerate the sample with water. Pour about 25 cc in a flask and add pure zinc and about 5 cc of HCl. If sulphides are present hydrogen sulphide will be liberated. To test for this, dip a piece of filter paper into a solution of lead acetate and suspend it in the flask. A black precipitate on the paper indicates the presence of hydrogen sulphide.

C. To Test for Artificial Coloring Matter.

This may sometimes be separated by macerating the sample with a mixture composed of equal parts of glycerine and water and a few drops of HCl. This is macerated for some time and filtered and then the filtrate tested for dyes as directed in Experiment 4, C.

Experiment 4. To Test Fruit Products such as Jellies, Jams, Syrups.

A. To Test for Salicylic Acid.

The test may be best made with liquids. Solids and semi-solids when soluble, should be dissolved in enough water to make a thin liquid. When insoluble they should be macerated with water and strained through a piece of white cotton cloth.

Pour about 50 cc of the liquid thus obtained into a bottle and

add a few drops of sulphuric acid. Shake for two or three minutes and filter into a small bottle. To this filtrate add about 25 cc of chloroform and mix the liquids by a rotary motion, but avoid shaking. Pour the mixture into a beaker and allow to stand till the chloroform settles out in the bottom. By means of a pipette remove as much as possible of the chloroform (which dissolves the salicylic acid) without the other liquid. Place this chloroform in a test tube and add about an equal amount of water and a piece of iron alum a little larger than a pin head. Shake thoroughly and allow to stand till the chloroform settles to the bottom. A purple color in the upper layer indicates the presence of salicylic acid.

B. To Test for Benzoic Acid.

The sample is prepared as in the previous experiment for salicylic acid. Then proceed also in the same way to add a few drops of sulphuric acid, filter, add chloroform, mix, allow to stand, and remove chloroform with pipette. Place this chloroform in an evaporating dish or beaker and put in the hood and float on a dish containing hot water, and allow to remain till the chloroform evaporates. Or the dish may be placed outside on the edge of the window ledge. The presence of benzoic acid is shown by the flat crystals which may appear, which, on being heated, give off an irritating odor. This test is not a delicate one and can be used only when the acid is present in large quantities.

If tests are to be made for both salicylic acid and benzoic acid, the chloroform extract obtained from the sample may be divided into two portions and one tested for benzoic and the other for salicylic acid.

C. To Test for Artificial Coloring Matter.

Place a few teaspoonfuls of the sample in water and boil to dissolve it. Place in this liquid a small woolen cloth or a few pieces of white woolen yarn. Boil for 5 or 10 minutes, stirring occasionally. Remove the cloth and wash in hot water. If the cloth is brightly colored the presence of artificial dyes is shown. Natural colors give a dull pinkish brown tinge. To make the test more certain, place the cloth in a solution of dilute ammonia made by mixing 10 parts of water with 1 part of ammonia. Boil for about five minutes and remove the cloth. The artificial coloring matter dissolves in the ammonia. If this is colored add HCl to it till the mixture is acid. Place in it a fresh piece of white woolen cloth and boil. Remove and wash in water. If the cloth is colored the presence of artificial dyes is shown. This

may be a coal-tar derivative as a vegetable color. Of the former, the cloth is usually turned blue or purple by the ammonia.

D. To Test for Glucose.

Pour a little of the sample into strong alcohol. If glucose is present, a white precipitate appears and settles to the bottom as a thick, gummy mass.

Experiment 5. To Test Canned Vegetables such as Tomato Ketchup.

A. To Test for Salicylic Acid.

Proceed as in Experiment 4, A.

B. To Test for Benzoic Acid.

Proceed as in Experiment 4, B. The acid is frequently present in sufficiently large quantities to be indicated by this test.

C. To Test for Artificial Coloring Matter.

Proceed as in Experiment 4, C.

Experiment 6. To Test Ground Coffee.

Spread the coffee out on a white piece of paper and examine with a magnifying lens. Chicory grains may be recognized by their dark gummy appearance, and cereal grains by their shiny polished surface.

Place a few teaspoonfuls of ground coffee in a bottle half full of water and shake thoroughly and allow to stand. Most of the coffee will float, while the chicory and cereal adulterants sink, coloring the water with a brownish tinge.

Some coffee substitutes will be found to contain some coffee if tested as just directed.

Coffee contains no starch, while most of the adulterants do. To test for starch boil the mixture a few minutes, allow to stand, cool, and add a drop of iodine. A blue color indicates the presence of starch and hence of some adulterant.

Experiment 7. To Test Spices.

A. To Test for Starchy Adulterants.

Cloves, mustard and cayenne contain practically no starch, so that the presence of starch is proof of adulteration. To test for starch see the last part of the previous experiment.

B. To Test for Coloring Matters.

Artificial dyes are sometimes used with yellow and brown spices to restore the color taken away by other light colored adulterants. Boil the sample in water to which a little HCl has been added. Filter and test as directed in Experiment 4, C.

C. To Test Mustard for Turmeric.

If turmeric is present in large quantities it may be tested by adding a few drops of ammonia and some water to the mustard. A brown color shows the presence of turmeric. This test will not show the presence of small quantities.

Experiment 8. To Test Baking Powder for Alum.

Put some logwood chips in an evaporating dish and cover with water and bring to a boil. Throw the water away. Do this three times but save the fourth solution. Fill a test tube about half full of water and add a teaspoonful of baking powder. Shake till effervescence ceases and add enough HCl to make the solution acid. To this solution add 4 or 5 drops of the logwood extract. A bluish red color indicates the presence of alum. A yellow color shows its absence.

Experiment 9. To Test Extracts.

A. Vanilla Extract.

Evaporate a quantity of the extract to about one-third its original volume. Add enough water to restore the first volume. The resins will be thrown down as a brown flocculent precipitate. If no precipitate is formed, no pure vanilla extract is present. If a precipitate is formed, add a few drops of HCl, stir, filter and wash with water. Dissolve the precipitate on the paper in a little alcohol. Divide this into two portions. To one add a piece of ferric alum, to the other a few drops of HCl. If neither produces more than a slight change of color the pure extract of the vanilla bean was used. If there is a distinct change of color, extracts from other sources are present.

B. Lemon Extract.

To a test tube nearly filled with water add a teaspoonful of the extract. If real lemon oil is present, it will be thrown out of solution and will give a turbid appearance to the solution and will form a layer on top of the water. If the solution remains clear after diluting with water, very little or no oil of lemon is present.

Experiment 10. To Test Olive Oil for Cotton-seed Oil.

Mix in a bottle or flask about 25 cc each of the oil to be tested and Halphens reagent. Place the flask in a vessel containing a boiling salt solution and heat for 10 or 15 minutes. A distinct reddish color indicates the presence of cotton-seed oil in small quantities, and a deep red, in large quantities.

(Halphens reagent may be made by dissolving one-third of a teaspoonful of precipitated sulphur in 3 or 4 oz. of carbon bisulphide. This is then mixed with an equal volume of amyl alcohol.)

**PRACTICAL EQUATIONS OF MOMENTS.**

BY F. C. VAN DYCK.

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If a rod A—B—C is crossed at the points A, B, and C by parallel forces, the force at B being opposite to the others and equal to their arithmetical sum, then there is statical equilibrium of the forces. An equation of moments can be stated with reference to each of the three points as an axis, and there is no ground for choice between the equations because neither of them is practical so long as no work is implied.

But let a fulcrum be placed at B, a weight at A, and an applied force ("power") at C, then we have a lever for which an equation of work can be stated. If  $d$  be a very small distance moved by the power, and  $d'$  the distance simultaneously traversed by the weight, the work-equation is

$$Pd = Wd'$$

Now, of the three equations of moments which have been mentioned only one corresponds to this work-equation, and it is therefore the practical equation of moments for the case.

The obvious method of procedure is to seek stated distances on the lever which have the same ratio as subsists between  $d$  and  $d'$  and then to form an equation of moments.

In the present case we see that  $d:d' = CB:BA$ , hence our practical equation of moments is,

$$P \times CB = W \times BA,$$

and the axis of moments is B. The process here applied to a lever of first class (or order) is valid for a lever of another class.

Before applying the foregoing method to another specific instance, let it be noted that all cases of leverage can be put under two groups.

**GROUP I.**

This group includes those cases in which the vehicle of the power-agent is not moved by the power. There seems to be no controversy as to any case in this group, everybody admitting that the axis of moments (fulcrum) is on the vehicle. The vehicle may be the earth or some support resting upon the earth; it may be a platform-car, or a boat, or any moving thing upon which the operator places his lever with its fulcrum.

So long as the vehicle is moved by some extraneous agency no question arises as to location of the fulcrum.

## GROUP 2.

Under this come those cases in which the power moves the vehicle of the agent.

Familiar instances are, rowing a boat; moving oneself in a wheel-chair by pushing on its wheels; the boatswain's chair, or painter's scaffold on which he lifts himself by pulleys; rising on one's toes; etc.

In all these cases there is controversy as to location of the fulcrum, the preponderance of authority being against admitting that it is on the vehicle.

The case of the oar has been much disputed and it is probably as ambiguous as any in group 2, hence let us choose it for study by the method of stating an equation of work.

On account of symmetry, deal with one side only.

Let the hand be at C, the rowlock at B, and the resultant of water pressure on the oar-blade at A.

First, two data, not liable to dispute, are premised.

(1). In the oar, as in every lever, the force at the central axis is equal to the arithmetical sum of the forces at the ends.

(2). The forces at the ends are to each other inversely as the sections into which the oar is divided by the rowlock.

## WORK-EQUATIONS.

This is, in general:

Work done by hand on oar = work done by boat against water.

Taking  $P$  for the force applied by the hand,  $W$  for the resistance of the water,  $d$  for a (small) distance moved by the hand, and  $d'$  for the distance simultaneously traversed by the boat; the equation of work becomes,

$$Pd = Wd'.$$

Of these four factors,  $P$  and  $d'$  are unambiguous.  $W$  is determinable as follows:

The pressure on the rowlock is made up of two items; the force applied by the hand, and the reaction of the water on the oar-blade. (See datum 1).

The condition of applying force to the oar is production of an equal, and rearward, force transmitted from the rower's body to the rowlock.

The item dynamically effective at the rowlock is therefore the reaction of the water, that is, the pressure of the oar-blade against the water. The ratio of  $d$  and  $d'$  is now determinable from the equation  $Pd = Wd'$ , which shows that  $W:P = d:d'$ .

Referring to datum (2) we have  $W:P=CB:BA$ .

Hence  $d:d'=CB:BA$ ; that is, the distances traversed by hand and boat are to each other as inboard section of oar is to its outboard section, and not as total length of oar is to its outboard section.

#### EQUATION OF MOMENTS.

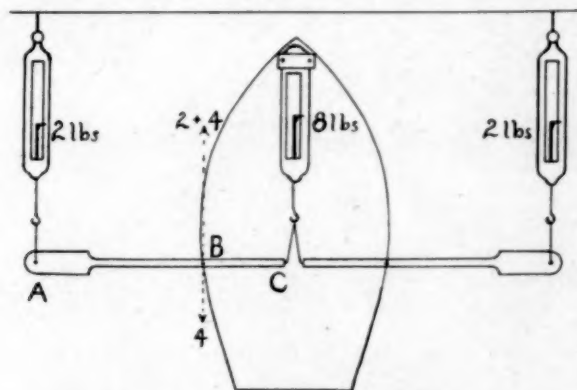
The practical equation of moments for the oar is,

$$P \times CB = W \times BA.$$

The axis of moments is therefore at B.

In all cases under group 1 the fulcrum is fixed relatively to the vehicle of the power-agent, and it may also be incidentally fixed relatively to the earth or to water bearing the vehicle. The result of the foregoing study of the oar is that in one instance, at least, under group 2, the fulcrum is fixed relatively to the vehicle of the power-agent.

The appended diagram shows one of the experiments which the writer has made.



The model weighs 4 lbs., as shown by suspending springs.

The ratio of AB to BC may be varied, by putting the suspending springs nearer to the rowlocks; as shown in the diagram the ratio is two to one.

Experiments prove that as long as the balance is attached to the bow of the boat the pressure on *oar-blades* is equal to the resistance offered to the boat's advance; but if the balance is detached and pulled by an extraneous agent then the total pressure at *rowlocks* is equal to the resistance to advance. The balance hook is joined to inboard ends of oars, of course, in all experiments.

## A SIMPLE FORM OF POLARISCOPE.

BY FREDERICK H. GETMAN, PH.D.

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The efficiency of a pile of glass plates as a means of polarizing light has long been recognized by instrument makers and the best projection lanterns are today fitted with an elbow tube containing a bundle of plates for experiments with polarized light. The majority of high schools, however, are limited in their equipment of physical apparatus and few are provided with the necessary appliances for exhibiting even the simplest phenomena of polarized light.

It is with a view to putting within the reach of any physics teacher the means of illustrating to the individual members of his class some of the more important phenomena of polarization, that I describe the following simple piece of apparatus.

While the light reflected from a bundle of plates inclined at an angle of  $57^{\circ}.5$  to the incident ray is polarized in the plane of incidence the light transmitted through a pile of plates inclined at the complement of this angle is found to be polarized perpendicularly to the plane of incidence.

The suggestion is made in Edser's *Light for Students*, that a pile of microscopic cover glasses might be arranged in such a manner as to yield a simple device for studying some of the polarization phenomena.



FIG. 1.

A piece of glass tubing  $\frac{1}{2}$  inch or more in diameter and about 6 or 8 inches long is selected and the ends are well rounded in the flame. In one end of the tube is placed a diaphragm DD made either of wood or cork. About twenty microscopic cover glasses are selected and carefully cleaned and their combined thickness measured; then a piece of velvet cork is cut with a suitable cutter so that it will just fit tightly in the tube TT. The cork is then bored with a borer the diameter of the hole being larger than that of the diaphragm DD and then a slot is cut in the cork of thickness equal to that of the total thick-

ness of the cover glasses and inclined to the axis of the cylinder at as near  $32^{\circ}.5$  as possible.

The cover glasses are then fitted into the slot, care being taken to avoid soiling them with the fingers and the whole assembled as in Fig. 1. The glass tube TT is then covered with photographic black paper to prevent the entrance of light except through the diaphragm DD.

The mounting of the tube is shown in Fig. 2 where BB is a base carrying a support SS through which the polarization tube TT passed at right angles. Over the tube TT is slipped a ring cut from a cork, CC, and into this is fastened with sealing wax a knitting needle P which serves as an index or pointer of the circular dial DD which may be graduated into four quadrants.

The complete apparatus may now be used in connection with another similar piece in studying the phenomena of polarization, one half performing the function of polarizer while the other acts as analyzer.

The alterations in brightness at intervals of  $90^{\circ}$  can be followed very satisfactorily and by interposing sheets of mica or stained glass between the two tubes very beautiful effects can be observed.

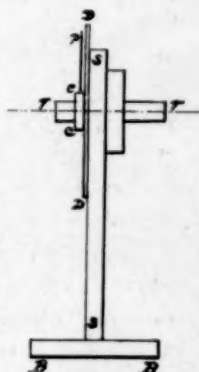


FIG. 2.

### BIOGRAPHY OF GEORGE ALBERT WENTWORTH.

BY B. F. FINKEL, PH.D.

*Drury College, Springfield, Mo.*

George Albert Wentworth was born in Wakefield, N. H., July 31st, 1835, and died while waiting for a train in the Boston and Maine Depot in Dover, N. H., May 24th, 1906. He was the youngest of eight children, five sons and three daughters.

Professor Wentworth received his elementary training in the district school and an old-time academy in his native town. In 1852, at the age of sixteen, he entered Phillips Exeter Academy, the institution to which he gave afterward his life service. While a student in this institution, he defrayed his expenses by his own earnings. From Exeter Academy, he went to Harvard, entering the sophomore class and graduating from Harvard with high honors in 1858.

During his undergraduate course at Harvard, Professor Wentworth taught several terms at Kingston and in the spring of 1858, was called back to Phillips Exeter Academy as instructor in Ancient Languages. A year later he was elected to the chair of mathematics which was made vacant by the call of its occupant, Professor Joseph G. Hoyt, to the chancellorship of Washington University at St. Louis. This position Professor Wentworth occupied and filled with consummate skill and ability until his resignation in the spring of 1892. In the spring of 1899, he was elected a member of the board of trustees of the Academy, rendering valuable service in that capacity until his death. In 1889-1890, the interval between the administrations of Principals Walter Q. Scott and Charles E. Fish, he was acting principal. Thus, as pupil, teacher, and trustee, Professor Wentworth was identified with the Academy for 45 years. He was liberal in his gifts to the Academy and to his influence it is indebted for gifts from others.

More than a generation of American youths came under the moulding influence of Professor Wentworth's wise, bracing, and stimulating instruction. The term "moulding" is here used advisedly; for he was a man keenly conscientious of his duty to his pupils. He had a strong determination and a carefully studied and fixed purpose and therefore was relentless in his efforts to obtain the highest expression of the student's powers. After all, it is not the lenient, unstable, catering, fawning teacher who moulds character and stamps his impress on his pupils, but rather the teacher with strong convictions, resolute purposes, a keen conscience, and lofty ideals.

In the recitation, Professor Wentworth would "roast" the indifferent and the disinterested. He reveled in both irony and sarcasm in his efforts to bring out the student's best thoughts, and it is said that the most sensitive could not help laughing even though they themselves were often the victims. All students coming under his instruction soon learned to look forward to his recitation hour and prepare themselves for it the more zealously. A lesson committed to memory was very distasteful to him; he wanted the student to work out results in his own way, and to this end he would employ his wits to trip those whose only reliance and recognized authority was the testimony of the text-book. One of his students says: "A student noted only for boundless good nature and a genius for sliding along without

taking the trouble to study, was sent to the board to work out a demonstration in geometry. He had scarcely begun when Wentworth cried out, 'Hold on, there, you are not doing that right.' The reply was, 'Mr. Wentworth, your book is wrong and I can prove it.' 'Go ahead and prove it,' came from Wentworth instead of the basting we were all looking for; but he watched the proceeding on the board with intense interest until it was finished and then promptly said, 'You are right, Darlington, the next edition of the book will give it your way.' The same student says: "We knew he would stand by us if right and we knew what to expect if wrong without good and sufficient reason. He would flunk a boy who had made a perfect lesson but who was otherwise deserving of censure, as easily as he was ready to help the poor recitation of one who was faithful to the purpose of the school."

Out of the recitation room, Professor Wentworth was kind and sympathetic in his dealings with the boys, but he had no patience with the lazy or deceitful and after they were found out, they soon left school. The climate of Exeter Academy did not agree with them, as was explained by their parents.

Those were comparatively few and they naturally hated him; the others liked him and respected him and for years afterward they remembered him as "Bull" Wentworth, a name applied to him in recognition of his virile qualities and as an expression of affectionate regard. His appearance at alumni reunions was always an occasion to do him honor, and of all his possessions none was more highly prized than the silver plate inscribed with the demonstration of one of his theorems and the names of the donors, presented to him at the last reunion of the New York Alumni.

But were Professor Wentworth's reputation to rest solely on his services as a teacher, he would soon be forgotten. His merited reputation rests more largely on his ability to write teachable text-books. He was among the foremost writers of elementary mathematical text-books in America. Professor Cajori says: "If we were called upon to name the writer whose books have met with more widespread circulation during the last decennium than those of any other author we should answer, Wentworth."<sup>1</sup>

<sup>1</sup> History of the teaching of Mathematics in the United States, p. 294.

In the latter '70s, Professor Wentworth being dissatisfied with the classification of the theorems and demonstrations as given in all then existing geometries, began teaching geometry by giving demonstrations of his own, the pupils committing the same to note-books. This method was followed until 1878 when, in January of that year, the results of his method of teaching geometry was published under the title of *Elements of Plane and Solid Geometry*. This book immediately sprang into favor, and became the most widely used text-book on geometry in America. Although the book lacked in logical rigor, it was a real innovation in respect to attractiveness of appearance, method of arrangement, and form of expression. The book contained a number of characteristic features which readily commended it to thoughtful teachers. These features are enumerated by Mr. Wentworth in the third and fourth paragraphs of his preface to the first edition. The defects of the book have been pointed out by Dr. Halsted and others in the *American Mathematical Monthly* and elsewhere, and in most cases these defects have been rectified. The encouragement received from the recognition of his geometry led Professor Wentworth to publish other books on elementary mathematics. However, some of the works bearing his name were prepared almost entirely by other men.

The most important of the books bearing his name are, *Elements of Plane and Solid Geometry*, *College Algebra*, *Plane and Spherical Trigonometry*, *Complete Algebra*, *Advanced Algebra*, and *Analytic Geometry*.

*Algebraic Analysis*, Part I, by Wentworth, McLellan, and Glashan contains a large collection of examples and problems with hints and solutions of many of the more difficult ones. Wentworth's *Arithmetics*, *Algebras*, *Geometries* and *Trigonometries* number about 40 books. Many of them are only physical divisions of a chief book, gotten out to supply the peculiar needs of various schools.<sup>2</sup>

<sup>2</sup>The chief source of information from which this biography was prepared was *The Exeter News-Letter*.

**CURRENT TENDENCIES IN SECONDARY MATHEMATICS IN FRANCE.<sup>1</sup>**

By J. W. A. YOUNG.

*The University of Chicago.*

While in Italy we saw<sup>2</sup> a nation just entering upon its investigations, in France we have the nation that has gone farthest in putting twentieth century ideas into actual practice.

For years there has been unrest in the pedagogic field in France. A prominent writer<sup>3</sup> has even gone so far as to anticipate a pedagogic revolution analagous to those of Copernicus in astronomy and Kant in philosophy.

Not satisfied with the important changes of 1880, of 1886 and of 1890, the agitation continued, culminating in the parliamentary inquest of 1899, which bore fruit in the reorganization of secondary instruction in 1902. Leading educators, representatives, publicists and officials, appeared before the commission, and made personal depositions on the educational problems submitted to them, followed by lively cross-questioning.

The stenographic report of the proceedings was published in five large folio volumes, aggregating 3158 double column pages, and constitutes the best, fullest and most authoritative work in existence on present-day secondary education in France. But its very voluminousness is so forbidding that M. Gustav Le Bon lays claim to be the only man in France, not excepting the commissioners themselves, who has read the whole of it.

I regret that time does not permit me to give even a brief account of the new curricula, with their four courses, Classical, Latin-Modern Languages, Latin-Scientific, Modern Language-Scientific, each in two Cycles, and all leading to the same degree and conferring the same rights.

In mathematics there remain as formerly two possible courses, the minor and the major; taken respectively in the first two and the last two of the four courses mentioned. In 1906, new curricula were again published.

The time given to mathematics under the curricula of 1891, of 1902 and of 1906 is indicated in table I, while table II gives the distribution of the subjects over the various years, in the classical courses:

<sup>1</sup> Address before the Mathematics Section, C. A. S. & M. Teachers, Nov. 30, 1906.

<sup>2</sup> See *School Science and Mathematics*, Vol. VII, No. 5, pp. 352-356.

<sup>3</sup> Bertrand, *Les études dans la démocratie*, Paris, 1900, pp. 17-21.

<sup>4</sup> Laisant, *L'éducation fondée sur la science*, Paris, 1904, p. 72.

TABLE I.

CLASS.	PREP.	8th	7th	6th	5th	4th	3rd	2nd	1st	Phil (or math)	TOTAL
Age		9	10	11	12	13	14	15	16	17	
1891	Classical			1	1	2	3	3	2+(1)	0	17½+(1)
Hours per week	1½	2	2						2	10	27½
	Modern			2	2	3	4	4	0	10	20½
									6	10	36½
1902	Classical Lat. Mod.			2	2	1+(1)	2+(1)	1	1	2	22+(2)
	3	4	4	3	3	4	3	5	5	8	42
	Lat. Sci. Mod. Sci.										
1906				2	2	2	3	1	1+(2)	2	24+(2)
	3	4	4	4	3	4	4+(1)	5	5	8	44+(1)

NOTES: (a) Numbers in parentheses denote *electives*.

(b) Geometric drawing receives considerable attention in the scientific courses, but the time allotted to it is not included above. It is classified with drawing.

(c) The class *mathématiques spéciales* is not included above. In it boys of 18 receive 15 hours of instruction weekly in mathematics, besides 4 hours in descriptive geometry, and take up matter that is ordinarily included in the advanced undergraduate electives of our best universities and colleges.

(d) Since 1902, the pupil who does not take Latin must take the maximum course in mathematics as in the table.

TABLE II.

Class.	Prep.	8	7	6	5	4	3	2	1	Phil.	
1891	<u>A r i t h m e t i c</u>					<u>Geom.</u>					
						<u>Arith.</u>		<u>Arith.</u>			
						<u>A l g e b r a</u>					
<hr/>											
1902	<u>A r i t h m e t i c</u>		<u>Includes Literal Ar.</u>			<u>Geom.</u>					
	<u>Intuitive Geometry</u>					<u>Arith.</u>		<u>Math.</u>			
						<u>Alg.</u>					
<hr/>											
1906	<u>A r i t h m e t i c</u>										
	<u>Intuitive Geometry</u>					<u>Geometry</u>					
						<u>Algebra</u>					<u>Math.</u>

As important features of more than local interest there may be mentioned:

In 1902.

1. Increase of the time devoted to mathematics.
2. Continuation of mathematics throughout the curriculum for all pupils. (Before 1902, pupils were permitted to omit mathematics in the last two years of certain courses).

3. *Extension of the subject matter.* The increase in subject matter in 1902 was of a most significant character. In 1891, the minimum was barely equivalent to our College Entrance Requirements. In 1902, there was added a year's work in mathematics, giving the pupil an introduction to the modern notions of graphs, analytic geometry and the elements of the calculus, with applications to the problems of elementary mathematics, to the phenomena of nature and the relations of human society. I have no time to go into details, but refer to J. Tannery's *Notions de Mathématiques*,<sup>5</sup> intended as a text for this last year's work, and confining itself closely to the material specified in the curriculum. This work from the pen of one of the ablest French mathematicians of today, and a leader in the forward movement in secondary mathematics cannot but prove interesting and stimulating to every reader.

In 1906.

4. *Further increase of time devoted to mathematics.*
5. *Addition of extended pedagogic instructions* to the curricula, bringing more explicitly into the foreground the ideas underlying the programs. Most of these are of course of a standard character. As significative of a tendency, there may be cited:
- I. Emphasis on order from concrete to abstract.
  - II. Free use of intuition, experience and experiment.
  - III. Experimental certitude to be recognized. Logical certitude its complement and legitimate outcome. The pupils should be led to see through many instances, that logical reasoning may reduce the experimental facts to a minimum and will cure their uncertain or approximative character.
  - IV. Motion to be used freely in geometry.
  - V. Drawing to play an important role in geometry.
  - VI. Close interrelations between different parts of the course; geometry and algebra, trigonometry and geometry, infinitesimal methods in geometry.
  - VII. Plane and solid geometry may be united to advantage in the later years.

<sup>5</sup> Paris, 1903, pp. 352.

VIII. The value of mathematical "recreations" is recognized (for perhaps the first time explicitly in an official curriculum).<sup>6</sup>

6. The actual changes in the matter to be taught are, so far as we are concerned, of a minor character, and may be described as in large part intended to round off corners in the curriculum of 1902, in part also to amend details so as to bring out more clearly the ideas that animated this curriculum. For us, the chief import of the changes is a negative one, that no changes are made except such as are in harmony with the radical changes made in 1902.

To sum up: In this and the preceding paper we have seen the same tendency at work in two countries; in the one in its incipency, in the other with a large measure of fruition,—now tested, and not found wanting; a tendency to make the teaching of mathematics more concrete, to reach its logical glory by a psychologically sound path, to bring its different branches into closer touch, to use freely all modern ideas that may prove helpful in the work. It is a tendency with which, I am sure, we here today feel the warmest sympathy, rejoicing in the achievements of our colleagues across the water and determined each to contribute what lies in his power to our own more or less analogous American forward movement.

I do not enter extensively upon comparison of the conditions discussed with those in America, but mention two points.

1. The mathematical movements mentioned are but minor phases of far reaching changes. We Americans justly feel proud that we are little trammelled by precedent and tradition; that a certain thing "has always been so" is not to us much of a reason why it should not be replaced by something better; yet in matters of educational policy we are the most timid and conservative of the world's great nations.

2. To particularize: Though the question of the simultaneous teaching of geometry and algebra has been before us many years,<sup>7</sup> yet little if any general advance has been made.

<sup>6</sup> Mention should be made here of C. A. Laisant's *Initiation mathématique* (Paris, 1906, (pp. 167) which uses entertaining mathematical problems to arouse interest in important principles and gives the teacher a valuable fund of material which, if, suitably used, would undoubtedly enliven the instruction.

<sup>7</sup> See, for example, Cajori's *Teaching of Mathematics in U. S.*, Washington, 1890 p. 359.

The *theoretic* reasons in favor of such a change have often been urged; that an experiment along this line could not *practically* prove very disastrous, is guaranteed by the concordant and satisfactory usage of the leading European nations. Such an experiment could be made by any one school without disturbing its relations either with the schools that fit for it, or the institutions for which it fits; the experiment could be made by the department of mathematics itself, without altering its hour schedule, or its relations to other departments. Has not the time come for a little conservative experimenting along this line? Do not misunderstand me. I am not proposing a "fusion" of algebra and geometry for a first, conservative experiment. I am not even proposing any very thorough interweaving of the two, but simply a juxtaposition in time; that they be taught simultaneously throughout the years in which they are now taught separately; that the long estrangement between algebra and geometry be healed; that they march along side by side, ready and willing to lend each other a hand on occasion. Within these limits, that are surely safe, and not expecting the best results on the first attempt or the second, would it not be worth while to give the *simultaneous teaching of algebra and geometry* a thorough trial?

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#### APPARATUS FOR THE DETERMINATION OF THE COEFFICIENT OF LINEAR EXPANSION OF A METAL TUBE.

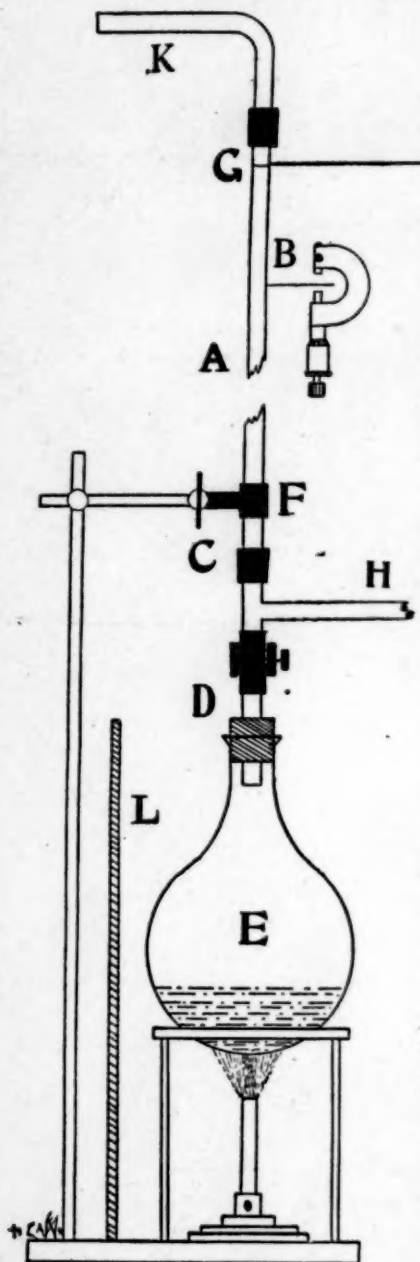
BY E. T. BUCKNELL,

*St. Philip's Grammar School, Edgbaston, Birmingham, Eng.*

The apparatus for this determination may be fitted up quite easily from materials generally in use in a physical or chemical laboratory. As a rule, the determination of a coefficient of linear expansion involves a somewhat costly piece of apparatus, and, moreover, the experience of fitting up is denied the student when he is provided with the finished article. Beyond a few metal tubes, which may be obtained for a few pence, the following method is cheap and simple, and, if performed with the care and precaution which one may reasonably expect from a second-year student, is capable of yielding very fair results.

A long tube  $a$  of, say, brass, more than a metre long, has a

needle soldered (eye end) to it at *b* about two inches from one



end. The end of the tube remote from *b* is fitted, by means of a short piece of indiarubber tubing, to the three-way tube at *c*. Continuing down, the three-way tube is fitted, by means of a piece of indiarubber tubing carrying a screw pinch-cock, to the outlet tube *d* of the glass flask (or tin can) *e*, which is used for generating steam. The brass tube is tightly clamped at *f*, and is maintained vertically by a ring of copper wire, clamped to a retort stand, at *g*. A micrometer screw-gauge, reading to the 1-100th of a millimetre, is clamped firmly in position at *b*.

A determination is carried out in the following manner: Screw up the pinch-cock at *d* until the passage into the flask is completely closed. Connect *h*, by means of rubber tubing, to a cold-water tap, and turn on the latter until a fairly rapid stream of water passes up the brass tube and out of the exit tube at *k*. (The latter is a piece of glass tubing bent at right angles and attached to the top of the brass tube by means of rubber tubing. It is preferable to have this el-

bow tube in communication with the sink by means of either glass or rubber tubing.) Take the temperature of the water after it has been passing for a few minutes; this will be the temperature of the brass tube.

Now measure carefully, with a metre rule, the length of the brass tube between the bottom of the needle and the point at which the tube is clamped, and then adjust the micrometer screw-gauge so that the top of the screw just touches the bottom of the needle. There is no difficulty whatever in making this adjustment as long as there is a good light behind the gauge and needle, *e. g.*, a window. Note down the reading of the gauge.

Turn off the cold-water tap, open the pinch-cock at *d*, and place a Bunsen burner under the flask. When the water boils steam will pass rapidly up through the brass tube and out by the exit tube at *k*. It will now be seen that the needle has moved away from the top of the screw, due to the vertical expansion of the tube.

After the steam has passed through the tube for some little time, and there is no further expansion, adjust the micrometer screw-gauge so that the top of the screw just touches the bottom of the needle once more, and again take the reading.

The necessary data for the calculation of the coefficient of linear expansion of the tube has now been obtained. The following example is the result of an experiment carried out by a student in the school laboratory:—

Length of brass tube = 1000 mm.

Temperature of cold water =  $12.3^{\circ}\text{C}$ .

Temperature of steam =  $99.3^{\circ}\text{C}$ . (Barometer = 741 mm.)

1st reading of micrometer screw-gauge = 4.18 mm.

2nd reading of micrometer screw-gauge = 2.56 mm.

$\therefore$  Expansion through  $87^{\circ}\text{C}$ . = 1.62 mm.

Then 1000 mm. of brass tube expand 1.62 mm. through  $87^{\circ}\text{C}$ .

$\therefore$  C. of E = 0.000186

The following tubes, diameter about 2-5ths of an inch, are suitable for determinations similar to the above: iron (0.000012), brass (0.000019), copper (0.000017), and glass (0.0000086). Since the needle cannot be fused into the glass tube, owing to the difference in expansion of glass and steel, a short piece of platinum wire may be fused in to take the place of the needle.—*School World*.

### A SUGGESTION FOR PRESENTING THE IDEA OF WEIGHT EXERTED AT THE CENTER OF GRAVITY.

BY HENRY S. CURTIS.

*Boys' High School, Brooklyn, N. Y.*

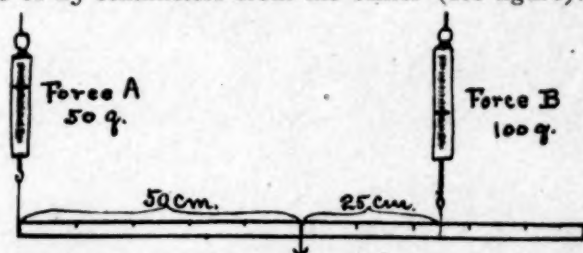
A difficult idea to present to students of the high school age is that involving the fact that the weight of a body may be regarded as a single force acting at its center of gravity. The experiment of determining the weight of a lever (generally a meter stick), is taught in most high school laboratories. The student is told, first to find the center of gravity of the stick, by balancing on a fulcrum, and then, displacing the fulcrum to some other position on the stick and counterbalancing, to find what weight, acting at the center of gravity of the stick, would have the same moment as the counterpoise. This unknown weight proves to be the weight of the stick itself and the student verifies by weighing on a balance. So far, so good. But in a class of average intelligence many will wish to know why the unknown weight should be located at the center of gravity of the stick any more than at any other position, and why this weight should be the weight of the stick when only a portion of the stick is on that side of the fulcrum. It is true that this difficulty may be met in a way, by showing that the moment of the excess portion of the stick on the one side (assuming, of course, that the stick is uniform throughout), is equivalent to the moment of a weight equal to the weight of the stick and located at the center of gravity. But to prove this, the distance of the excess portion of the stick must be measured from the fulcrum to its center of gravity, which is attempting to prove a fact by assuming what is to be proved. An algebraical method of presentation may be employed but is open to the same objection.

To tell a class beforehand definitely what they are to find out or to lead them to conclusions that do not appeal to their reason, is to rob an experiment or demonstration of its chief value.

The author has found the following method of presentation of the subject much more logical and helpful and not too hard. It is utilized to best advantage as soon as possible after the question of the equilibrium of three parallel forces has been discussed and preferably after the experiment relating to such has been performed in the laboratory.

The class has learned, 1st, that if three parallel forces are in equilibrium, the single force acting one way, is equivalent to the sum of the other two forces, and 2nd, that the two forces acting together, are to each other inversely as their distances to the line of direction of the resultant. While these ideas are still fresh in the minds of the class, proceed as follows:

Suspend a meter stick from two fairly sensitive draw scales, so that the stick rests horizontally and the cords supporting it are approximately perpendicular to it. Attach the cords leading from the scales at different distances from the center of the stick, say for convenience, one at the end and the other at a distance of 25 centimeters from the center (see figure).



Ask the class if the condition is that of three parallel forces: they will see without difficulty that it is and that the single force is the weight of the stick itself. Suppose that the combined readings of the draw scales is 150 grams. Scale A will then register 50 grams and scale B 100 grams. Ask the class where the single force must be applied to give such readings and they will say that, since the forces are to each other inversely as their distances, that force B must be half as far from the single force as force A. Where then must the single force be to satisfy the conditions? The answer will be, at the center of the stick (in this case its center of gravity also). But this single force is the weight of the meter stick. It therefore follows that the weight of the stick may be regarded as a force applied at its center of gravity. A number of trials will strengthen this conclusion.

Such a method of presentation has several marked advantages. It is simple and logical; it is based on ideas readily assimilated and understood by students of average intelligence; it leads to conclusions that most students will appreciate and recognize as reasonable and definite.

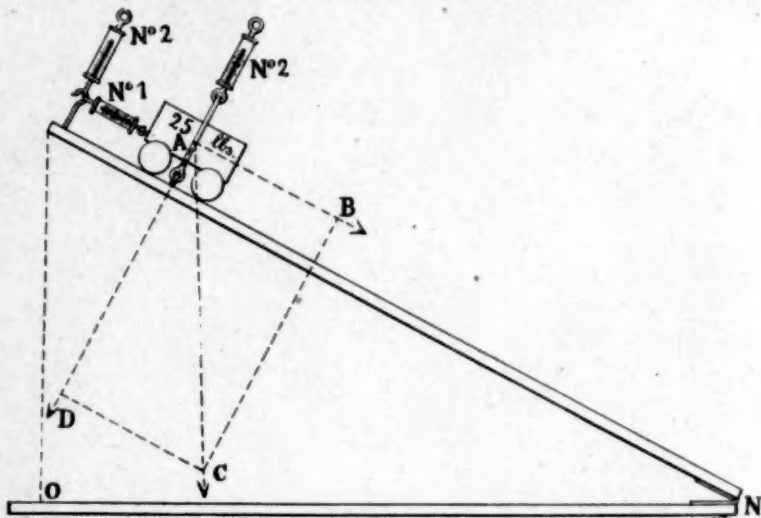
No originality is claimed for the method; it is doubtless used by many teachers. But for those who have not tried it, it was felt that the idea might prove helpful and hence the foregoing.

### A DEMONSTRATION OF THE DECOMPOSITION OF GRAVITY BY THE INCLINED PLANE.

BY FRED D. BARBER,

*Illinois State Normal University.*

Almost any plane suitable for use in laboratory work can quickly be prepared for this experiment. The writer uses planes made of 12" pine boards, 3'-6" in length. Two of these boards securely hinged at one end constitute the bed and plane. About three inches from the free end of the plane a screw hook is inserted in the center of the upper surface of the plane. Spring



balance No. 1 is hooked over this hook and onto the car. Spring balance No. 2 is merely hooked into the screw hook. The instructor then lifts the plane by means of balance No. 2, always pulling at right angles to the plane. Balance No. 1 evidently gives the component of gravity which is parallel to the plane, while balance No. 2 gives the component which results in pressure against the plane. As a quantitative experiment, or a merely relatively quantitative experiment, the arrangement described is sufficient.

If it is desired to make this experiment more quantitative, a screw hook must be inserted in the plane at either side and opposite the center of gravity of the car. The two ends of a cord may then be tied into the screw hooks and balance No. 2 hooked into the loop above the car. The slope of the plane, i. e., the height and length of the plane, may then be taken at the same moment that the reading of each of the balances is taken. These readings may be taken at as many different angles of the plane as may be desired.

**ELEMENTARY BACTERIOLOGICAL STUDIES.**

BY WILBUR H. WRIGHT,

*McKinley High School, Chicago.*

No one can doubt the importance of the study of bacteria in courses in botany and hygiene, but the difficulties of technique and the time required for preparation have prevented such studies from being generally undertaken in secondary schools. The usual methods of making, neutralizing and sterilizing gelatin and agar media require too much time and experience. This has brought about a wide use of the potato as a culture medium, but no opaque medium can compare with a transparent one for this work. The potato also often resembles the bacterial colonies in color and no separation of colonies can be made in a solid medium.

Of course the ideal medium would be one which is faintly alkaline, nutritive, sterile, transparent, and capable of being liquefied and used without much preparation. Searching for better simple media I have tried to devise some methods of using the raw white of egg, some fruits, gum tragacanth or starch compositions but without success. The following simple methods, however, have given good results. The time stated as required is approximate.

A. Potato. Cut potatoes in half, boil ten or fifteen minutes, immerse while hot in a hot solution of aniline blue. The boiling may be done in the aniline solution. Transfer with sterile fork to sterile jelly glasses, containing a little sterilized water. Time required, twelve to eighteen minutes. The colonies, formed after inoculation, generally remain uncolored and a pellicle may be found and studied on the water in the glass. Gas bubbles may often be seen.

Aniline black is ordinarily hard to obtain at drug stores but a commercial black dye, presumably aniline, proved satisfactory also in coloring the potato. A strong litmus solution or paste gave good results and those obtained with black ink were fairly good. The litmus has the advantage of indicating acidity but it is more difficult to color the potato evenly with it. Uncolored carrots are suitable for this work. Beets and potatoes stained with aniline red or red ink are less satisfactory, staining the bacterial growths red. Sweet potatoes and parsnips, unstained, gave only fairly good results, their color not contrasting so well with those of the colonies. The colonies show more plainly on ordinary uncolored potatoes if the potatoes have been boiled with a little gelatin.

B. Beef broth. 1. Dissolve  $2\frac{1}{2}$  grams of Liebig's extract of beef in 1000 c. c. of boiling water. Time required, 5 minutes.

2. Boil one pound of lean chopped beef in a little water for from thirty to sixty minutes. Filter and dilute to one litre. Time required, forty to ninety minutes.

Place a part of the broth obtained by either of the above methods in test tubes, each about one fourth full, plug with cotton, place tubes erect in water a little deeper than the medium in the tubes, cover the vessel and boil for twenty minutes on three successive days.

C. Gelatin. To 500 c. c. of broth (above) add 60 grams of sheet gelatin and raise the temperature slowly. Do not boil. When dissolved add a solution of sodium carbonate, carefully, till faintly alkaline to litmus. Time required, ten to twenty minutes. Pour into tubes, sterilize on two successive days for twenty minutes. Do not heat more than is necessary. Place the tubes in a slanting position while cooling after sterilization.

D. Agar. To 500 c. c. of broth (above) add 10 grams of agar. Boil till dissolved, add sodium carbonate solution *slowly* till faintly alkaline and pour into tubes. Time required, twenty to forty minutes. Sterilize by boiling for fifteen minutes on each of three successive days.

Media should be made in the presence of the pupils if possible.

Suggested Exercise. Time, two to four hours. 1. Preparation of colored potato media or carrots. Inoculate from water, milk and dust, respectively, and set aside. Also set aside a few sterile dishes of media for controls.

2. Preparation of beef broth tubes. Inoculate as before and add a drop of formalin to some of the tubes.

3. Preparation of agar or gelatin tubes. When liquid and not too warm inoculate and pour contents into sterile Petri dishes. Allow some tubes to harden in a slanting position and inoculate. Put one or two on ice.

4. When colonies develop describe their size, shape, color, number; note the odor of the cultures. Compare the controls. Solid media should be examined for evidence of gases, liquid media for any pellicle formed on the surface or any sediment or cloudiness; gelatin for any trace of liquefaction. Note changes from day to day.

5. Describe live bacteria under high power (if possible use one-twelfth objective). Use stained slides showing different forms and make a classification based on form.

6. Discuss occurrence, variation in size, form, motility, color, and appearance; classification, identification, food, economic relations, use of antiseptics and sterilization based on above studies.

The following topics are suggested for library, essay work and discussion:

The following topics are suggested for library, essay work, and discussion: -

1. Tuberculosis.
2. Typhoid fever.
3. Smallpox and vaccination.
4. Diphtheria and its antitoxin.
5. Pneumonia and influenza.
6. Public health, officers, methods and regulations.
7. Fermentation, sterilization, antiseptics, and preservatives.
8. Nitrification.
9. Some bacterial diseases of plants.



Scene in Grand Canyon, Santa Fe Railroad

**ANOTHER POINT OF VIEW IN CHEMISTRY.**

BY FREDUS N. PETERS,

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In the February issue of SCHOOL SCIENCE AND MATHEMATICS appeared an article by Dr. Alexander Smith, of the University of Chicago, under the caption, "The Point of View in Chemistry." In many respects the article is worthy of the highest commendation, but in others, it seems to me, its suggestions need careful consideration before being adopted. Allow me to say at the very beginning that in many ways I am indebted to Dr. Smith and his co-laborers at Kent Laboratory for their many courtesies during the whole or part of three summers; and further, that for fear of being considered presumptive I have hesitated long before attempting to speak at all. He sees things from one viewpoint, however, and I from another, hence this reply.

As he says, the field of chemistry is an exceedingly large one, and in one year we cannot hope to take a very complete survey of any portion of it. In a general way it seems to be agreed among chemistry teachers as to what portion shall be considered during the first year. But just how, or when, any particular part shall be investigated, according to Dr. Smith, does not seem to be very well agreed. It is probable, however, that wherever we enter, we shall occasionally have need of something found in other portions of the field. For example, I believe the subject of valence, logically, should not be studied till after hydrogen, oxygen, chlorine, nitrogen and possibly carbon, together with their more common compounds. In my lecture room, till after a formal study of the subject has been made at the time indicated, the word valence is never allowed utterance any more than if it did not exist; and yet, often, some exploring student who has ventured considerably beyond the confines of our present clearing makes inquiries that might well need something of the work in valence.

I believe, and I am of the opinion that most chemistry teachers likewise believe, that theory should not be introduced till a greater or less number of facts demand an explanation. Believing this thoroughly, I have for a long time attempted seriously and conscientiously to practice it. Nevertheless, while this is good doctrine, yet we may carry it to such an extreme that we shall very seriously retard the progress of the student without accomplishing anything except being true to a pet theory.

Dr. Smith asks as to the manner and time of introducing the atomic theory. In high school chemistry probably there is little need of going into the subject at all except in the simplest way. It is supposed, however, that in most high schools, at least in the larger ones, the subject of physics has preceded that of chemistry. If so the student has had discussed at various times the constitution of matter. The general properties of matter, divisibility, porosity, compressibility, have brought him face to face with the idea of a molecular structure of bodies. He has been taught to discard the fluid theory of heat and accept the molecular theory; he understands that the truth of Boyle's and Charles' Laws depends largely upon the molecular theory of matter; magnetic and electric induction, likewise, assume the truth of the molecular theory. So at various times during the year he spends in physics, he has impressed upon him the idea of the molecular composition of matter.

It is but a short step, therefore, after he has reached this point to come to understand that molecules may be composed of atoms, and in addition the few other phases of the atomic theory which he may need.

The idea that each atom has a particular weight and that when combination takes place it is always in the ratio, or multiples, of this particular weight, undeniably led Dalton to formulate the atomic theory. This part of it may well be left till the study of quantitative laws is taken up, but I can see no objection to reviewing briefly very early in the course in chemistry, the molecular theory of the composition of matter and introducing the basis of the atomic theory, at least that part of it which assumes the existence of atoms as the constituent parts of molecules. But to allow the atomic theory "to explain the fact of chemical combination" or any other theory to explain any observed phenomenon is entirely out of the question.

I believe no chemistry teacher can go far without being compelled to use a portion of the atomic theory. All, as far as I have observed, make use of the equation very early in the course. If we begin with water as the most familiar of all substances, we express in the form of an equation the experiment of electrolysis, and also of synthesis by the eudiometer, or by passing hydrogen over heated copper oxide. We may not use formulas at this early stage or we may do so. If we begin our real work with oxygen we probably require most of the equations, expressing the chemical

changes involved, to be written by the student. If we are using a text that has not dared thus far to introduce formulas for fear of violating some pedagogical principle, we expect the student to look them up elsewhere or "pump" the instructor. If he is of inquiring mind, which means, if he is of any account at all, he wants to know what a formula means, what a symbol represents. There are, therefore, some things about molecules and atoms which must be taught almost from the beginning. Set up our cameras where we will, focus them in what direction we may, we shall find some of these self-same molecules in the foreground. This does not mean, however, that they must necessarily assume gigantic proportions. Almost every metaphor fails at some point. And so here. They may be but pebbles that in the finished picture will not even be discernible; or they may be but friendly stones to keep one or more of the feet of our tripod from sinking into the soft and uncertain ground and thus ruining the picture entirely.

As to the study of oxygen and ozone. It is well enough that the student should know that "one is deep blue and the other pale blue, that one is easily liquefied and the other not, that one rusts silver and the other not;" but is this sufficient? Shall he be taught that they are both oxygen? If so, will he not certainly ask wherein lies the difference? Will he be satisfied to be told that ozone is "one half heavier than oxygen?" Will he not demand an explanation? Is it a very long step to say that the oxygen molecule consists of two atoms and the ozone of three?

Again, shall we say that the formula of hydrogen is written  $H_2$  "because there are two atoms in its molecule?" Shall we say that formulas represent molecules or "equal volumes?" If we say "equal volumes" will not the student ask, what are these "equal volumes?" Shall we tell them that the formula  $H_2$  represents a cubic centimeter of hydrogen or a quart? That  $N_2O$  represents a cubic centimeter, or a quart of nitrous oxide? Either fulfills the condition of "equal volumes," yet neither is the truth. Does the student have any idea at all of such definitions as are often found in text-books, for example: "the Volt is the E. M. F. which will cause unit current to flow through unit resistance." If we say "density is the number of units of mass contained in unit volume" we use a statement perfectly clear to the scientist or to the ordinary teacher, perhaps, but absolutely without meaning to the beginner, unless we illustrate by concrete

examples. Even then he grasps the idea but slowly. It is the difference between abstract and concrete expression. It may be unpedagogical to begin with theory but to express experimental results in abstract statements is not far removed from the same error. Some of us are "thick-headed," slow to grasp ideas; abstractions take but slow and feeble hold upon us, even though those abstractions may be simply expressing facts learned experimentally. The scholar is able to reason in the abstract, but the student for a considerable time must hold to the concrete.

Which of the following statements is easier for the student to understand? "The formula of hydrogen is written  $H_2$  because the molecule consists of two atoms" or because in "comparing equal volumes of hydrogen and hydrogen chloride, we find twice as much hydrogen in the former, and if we assume unit quantity in one, represented by  $H$ , we must conclude there are two unit quantities in the other to be expressed by  $H_2$ "? One of them is a theoretical statement, the other is the "language of experiment." The trouble is that the "language of experiment" is clothed in such abstract expression that the student in endeavoring to learn its meaning loses sight entirely of the experiment. Further, will he really see any reason for assuming unit volume in hydrogen chloride? May he not have taken some other compound with a smaller amount of hydrogen in it? As far as he knows, he might. He is as helpless and dependent upon the instructor as if he were told in the language of theory.

As to the nascent state, to me it seems difficult to explain exactly why the reduction by means of hydrogen, for example, takes place. Ferric chloride solutions with the addition of zinc, aluminum, magnesium, iron, tin, together with hydrochloric acid, are completely reduced. In every case except that of tin, and there another factor enters, the rapidity of the reduction depends apparently upon the rapidity with which the hydrogen is evolved. Since this is so is it sufficient to say that the action is catalytic? It is said that hydrogen from the cathode of an electrolyte has reducing powers but my experience seems to indicate that it is vastly slower than that of the same quantity evolved by metal in the presence of the solution to be reduced. We know that hydrogen in the molecular form (not nascent) has reducing power if heated strongly. May it not be that there is still another explanation which may be offered? I am not ready as yet to offer it, for it is not well shaped in my own mind, but I am inclined to

think there is another very plausible reason. Even if we accept the catalytic theory do we know any more than we did before? Are we not discarding one theory for another which is no easier of proof and which explains no better?

As to valence. There may be more scientific ways of defining the term than the one usually adopted by the elementary textbook; but would they be understood by the beginner? It is true that "zinc is said to be bivalent because an atomic weight of this element combines with two equivalents of chlorine or of oxygen, and displaces two equivalents of hydrogen." But is this saying more than that one atomic weight of zinc will displace two atomic weights of hydrogen? Or, to simplify even more, that one atom of zinc will displace two atoms of hydrogen? Dr. Smith says we deal with masses in the laboratory. True. Our students weigh out one gram of magnesium, cause it to displace the hydrogen from an acid; they collect the gas, reduce it to standard conditions, calculate its weight, and determine that to displace one gram of hydrogen twelve grams of magnesium are required. Similarly, experiments with iron, zinc and aluminum are tried and the students find that the metal equivalents respectively are in round numbers, 28, 31.5 and 9; but owing to their limited field of vision they are unable to draw any valuable conclusions.

Dr. Smith asks: "Why is zinc bivalent and why does one atomic weight of it displace two atomic weights of hydrogen? Is it not because its atomic weight contains two equivalents of zinc? And is not the valence of an element, therefore, also, the number of equivalents of the element contained in its atomic weight?" I answer, yes; and to such as Dr. Smith, who have investigated with great care much of the vast field of chemistry, such expressions are plain, but to the beginner they are hopelessly abstract. I believe Dr. Smith, himself, knows beginners do not grasp the meaning of such expressions. In his book published by the Century Company, after taking many pages to develop the idea of equivalents and combining weights, he says, (p. 51): "The reader will inevitably find difficulty at first in thoroughly grasping the significance of these numbers. It may, therefore, be of some assistance if a hint is thrown out which will suggest a concrete basis for this curious property. These numbers appear to mean that, when we wish to make a chemical compound, we may choose any two elements from the list, and, if it is found that they can combine at all, we have only to take

the *atomic weights*, worked out from other combinations of each element, and we shall find that they will exactly suffice for this case of chemical union. If complete combination of both materials does not take place, then trial will quickly show what multiples of the atomic weights will result in this. The situation seems to suggest that the constructing of chemical compounds depends upon the putting together of ready-made 'parts' like those of a watch or bicycle. The parts seem to be 'interchangeable,' and each element seems to be furnished to us by nature in ready-made packets suitable for application in building up any chemical structure."

If such suggestions are necessary for college students, how much more must be needed for those younger and less experienced. Furthermore, to understand Dr. Smith's method of explanation I believe the student must have already fairly good ideas of the atomic hypothesis. In the first five sentences (quoted above) which he uses to make himself clear that valence should be expressed in terms of equivalents, he uses the expression "atomic weights" not less than six times. Why should he do this? Is it because it is impossible to get away from some fundamental ideas? Try as we may, call them atomic weights or equivalents, we all mean the same thing. It is only a question of names. But I believe it must be admitted that the term "atomic weight" is not only more definite in its meaning but has other advantages over the expression "equivalent." If so, what do we gain by the change?

Did time permit I should like to commend some of the positions taken in the latter part of his "Point of View," but it is unnecessary. Nothing I could say would add anything to what Dr. Smith has said; what is more, nothing I have said may take anything from the force of what he has said. We evidently see things from different points of view. He deals with the mature student, I with the beginner. Unit volumes and equivalents are all right in their place but they are more or less of abstractions and therefore their place is not in the High School. To adopt them with beginners is to expose solio paper of the photographer to gaslight, when only the strong light of the sun is sufficient. Much weariness of the flesh, an almost absolute blank, except in a few cases of extra sensitiveness, and complete discouragement of both teacher and pupil, will be the result.

## COMMENT ON "ANOTHER POINT OF VIEW."

BY ALEXANDER SMITH.

While I am indebted to the editor for his courtesy in giving me the opportunity to comment on Mr. Peters' article, there is much that might be said, yet little that must be said. "He sees things from one viewpoint, and I from another."

In one or two places, however, I question whether we are seeing the same things at all. Thus, I feel that something more than a difference in viewpoint is involved when we read, "the truth of Boyle's and Charles' laws depends largely upon the molecular theory of matter."

Again he says, "But to allow the atomic theory to explain the fact of chemical combination, or any other theory to explain any observed phenomenon is entirely out of the question." Yet, further down, in connection with ozone and oxygen, we read "Will he [the student] not demand an explanation? Is it a very long step to say that the oxygen molecule consists of two atoms and the ozone of three?" This looks to me like, not one, but two other points of view. Can any meaning be attached either to the word theory, or to the word explanation which will reconcile these statements?

I tried to show that the atomic theory explains the quantitative laws, but fails to throw light on the qualitative facts which usually precede them. Mr. Peters, however, would introduce the theory at the earlier stage. His first reason, that the molecular theory has been previously studied in physics, would justify the discussion of photography and batteries before constant proportions because light and electricity are parts of physics. His second reason, that he "sees no objection to reviewing briefly very early in the course in chemistry the molecular theory" seems, from my viewpoint, unsafe. One may so easily overlook or fail fully to appreciate objections, that positive and thoroughly sound reasons for every decision of this sort should be demanded by one's pedagogical conscience before the decision is made.

The conception that the meaning of a symbol or equation can be stated only in terms of the atomic theory, as a consequence of which equations have to be postponed until after the atomic theory has been explained, does not appear to me to be consistent with facts, or, for example, with a common use of equations, namely in working simple arithmetical problems.

In the matter of  $H_2$ , there seems to be some confusion. I did not discuss the question of purely theoretical *vs.* purely abstract terms for expressing facts to beginners. That would be as fruitless a subject as discussing whether a neat menu-card or a photograph of a breakfast would best satisfy the appetite of a hungry pupil. I suppose we all agree that the third possibility, the experimental, gives the best results. I was not writing a paragraph for a text-book, but trying in the course of a highly condensed address, delivered, not to pupils, but to teachers of chemistry, briefly to characterize two views. It was the two possible viewpoints of the teacher, not the mode of presentation from either viewpoint, that I was discussing, for the latter would have been outside of the limits set by my title and enforced by the briefness of the time.

But, aside from the misapprehension of my purpose, Mr. Peters does make clear, in this connection, the point at which our views diverge. He thinks it involves the more abstract viewpoint if we reason: (1) that there are equal numbers of molecules in equal volumes of gaseous substances (at the same temperature and pressure); (2) that our formulae, being molecular, represent relative weights of equal volumes of gaseous substances (without this, neither Mr. Peters nor anyone else has any cause to use the formula  $H_2$ , rather than  $H$  at all); and (3) that, since 1 liter of hydrogen contains .09 g. of the element, while 1 liter of hydrogen chloride contains by measurement only .045 g., if the latter quantity be represented by  $H$ , the former must be represented by  $H_2$ . There are various ways of expressing this third step, of which this appears to be the most literal. Now I think the statement that one molecule of hydrogen contains two atoms, and that the formula of the gas is therefore  $H_2$ , is vastly more abstract. I assume, of course, that all necessary illustrations and every pedagogical art will be used in presentation, whichever point of view is in the teacher's mind. Suppose Mr. Peters to use the second point of view and his pupil to ask, "How do we know that there are two atoms in the molecule?" is Mr. Peters not then compelled to go into the explanation from the other viewpoint after all? If, therefore, the statement in terms of atoms, contains, implicitly, the longer statement, is it not *ipso facto*, the more abstract of the two? There still remains the question of whether the subject is an appropriate one for treatment in a high school course at all, and whether it is not rather of interest

only to those who are in college and are going on to more advanced work in chemistry. I took up the subject because it actually is handled in secondary schools, and I was not discussing the ideal content, but only the viewpoint in certain items of the commonly accepted content.

As to the nascent state, iron, zinc and other metals reduce ferric chloride without the presence of hydrochloric acid, so that no hydrogen need be evolved at all. The view which I presented is one now held by many chemists, including so eminent an authority in electro-chemistry as Prof. Haber of Karlsruhe, and is therefore entitled to more consideration than Mr. Peters accords it. If we accept the catalytic theory, perhaps we may not know a great deal more than we did before, but we do know this, that a single explanation, if it is ever found, will probably cover both catalytic and nascent action, whereas from Mr. Peters' viewpoint, two explanations are required. Simplification is one of the principles of the scientific method.

In regard to valence, my statements certainly would seem hopelessly abstract to beginners, but then they were addressed to teachers. Again, if our pupils can determine experimentally that 12 grams of magnesium displace 1 gram of hydrogen, but cannot utilize the result even with the assistance of the teacher, I fail to see how they can understand the more abstract way of stating the same result when the teacher informs them that one atom of magnesium displaces two atoms of hydrogen. Does Mr. Peters mean that they have to learn the latter form of the statement off by heart? What good can it then do them, when so learned? His remarks, if they represent the experience of many teachers, seem to show that we should not try to teach valence in any form in the secondary school. Its case seems to be somewhat like that of  $H_2$ . Finally, the quotations from my *Introduction to General Inorganic Chemistry* cannot be judged without careful examination of the context. But Mr. Peters seems to criticise me for venturing to introduce the atomic theory on p. 51 after I have completed the discussion of the quantitative laws (which I indicated in the Point of View to be the place where it should go), although in the opening part of his paper he contends that it ought to be put in much earlier. He is difficult to please. More space is taken up with the atomic and molecular theories in the work referred to than in any other with which I am acquainted! But my viewpoint is such that I cannot accept as conclusive the reasons, photographic or otherwise, which favor the use of these theories in chemistry before the quantitative laws are discussed.

**HIGH SCHOOL PHYSIOLOGY.\***

MISS GRACE FRANCES ELLIS,

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Several years ago it seemed necessary and wise, in our school, to establish in the 12-2 grade, a class in physiology, where those students who were preparing for teaching in country schools, or for entrance to Normals, could have such preparation as they needed. To this group was added that small number of pupils, who by reason of themselves being older and more thoughtful, or by advice from parents or friends, thought it wiser not to leave school where they had gained some acquaintance with almost everything else, without some knowledge of themselves. With such a class of students and for their needs so far as they could be ascertained, I have worked in several successive classes. Admission to this class does not depend altogether on position in grade. Students other than seniors have entered it, when it has seemed best to let them; though this is not the general rule.

Martin's Human Body has been our text-book, with Peabody's and several other texts for reference. Almost equally with Martin we have used State Board of Health Reports, publications of the United States Department of Agriculture; occasional magazines and other periodicals; and even statistics collected from jails, asylums, and other institutions.

Students who elect this subject are sometimes prepared for it, but more often are not. They will almost without exception have had a semester of physics, but often have had no chemistry, occasionally only, they have had botany or zoology. When the course was first given we started in on bones, according to the order in Martin; we do so no longer. I do not even now know why bones are of so much less interest at this stage of the game; but I know they are and I am willing to abide by my experience. So far as I have been able to learn, fresh bones are "mussy," and dry ones "dirty and rattley," but I no longer mention them to my beginners.

In the class room we begin the work with some simple experiment, such as the burning of a match, and from this work out the ideas of chemical change, elements, compounds, and the like. This is usually followed by a study of air with prepara-

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\*Read before the joint meeting Biological Conference and Science meeting of the Michigan School Masters' Club March 29, 1907.

tion of oxygen and nitrogen before the class; and after this we study the chemical composition of the human body.

Peabody's *Studies in Physiology*, gives an excellent introduction to the subject for pupils who have had no chemistry. By this time the class is ready for some introductory laboratory work, and we begin with a set of experiments on acids and alkalies; perhaps the simplicity of these should be emphasized: students are told to test them with Litmus paper; to taste them in dilute solutions; to neutralize the two and evaporate; and finally to give definitions drawn from these experiments, of an acid, an alkali, a neutral substance, and a salt. At the close of the period each pupil is given some pieces of Litmus paper to take home; is asked to test as many substances as possible, and to record the results obtained under proper headings. At the outset it is important to emphasize the fact that physiological processes can never be understood unless the pupil is given some idea of the simpler principles of chemistry. He must be familiar with carbon, hydrogen, oxygen and nitrogen; he must know how to test for carbon dioxide, for acids and alkalies; he must learn something of the common processes of oxidation, neutralization, and evaporation. For unless these lessons are taught early in the course, and taught by experiment, the foundation will be weak when the more difficult processes involved in digestion, respiration, and excretion, are reached. If a pupil once gets clearly in his mind the nature of elements, compounds, and the process of oxidation, an immense amount of subsequent labor and disappointment will be saved. Class work in the text is commenced with Chaps. VIII and IX, "Why We Eat and Breathe," and "Nutrition," from Martin.

In the study of foods the student first tests for the five or six nutrients found most commonly in foods. For the starch tests we give each student a small bottle of iodine solution, and let him conduct his tests at home. When he has followed the simple directions given him, and has tested ten to twenty foods, he is ready to report in the class room. He knows whether starch is most likely to be found in foods of vegetable or animal origin. Food adulteration has commonly come up for consideration in the class from the conflicting results furnished by the testing of spices. The sugar test, by Fehlings' solution can easily be done at home, if pupils are furnished with test tubes, and a small supply of the solution. The presence or absence of

fats, proteids, minerals, and water may be determined at home, or in the laboratory, by the individual pupil, and results compared in the class room. Such a course leaves the pupil with a concrete idea of the important compounds he will meet with over and over again, in the ingredients of his food; as components of the blood; or constituents of tissues in the body.

It is, of course, impossible to demonstrate by experiment the uses of these various nutrients, and so with laboratory or home work there must be a liberal amount of class room instruction. Very often a pupil does not see, without vigorous and exhaustive questioning, what are the essential points in each experiment, and the relation of the various facts which have been accumulated.

So much accustomed are we as teachers to the combining of these various results that we forget that the end, plainly in view to us, is hidden from the pupil, and relationships are more or less vague and misty to his mind.

The uses of foods, proper methods of cooking, food economy, and the relation of diet to health, are, to my mind, the most important topics included under human physiology. Most high school text-books give a rather inadequate treatment of the subject, but the publications of the United States Department of Agriculture are to be obtained even in the large quantities necessary for individual study; the best bulletins for high school use are "Principles of Nutrition, and Nutritive Value of Foods," "Meats, Composition and Cooking," and those on milk, bread-making, fish, and eggs.

The colored food charts which are so useful in class recitations, are unfortunately out of print, but the same charts and tables are given in the bulletins mentioned. While the study of the digestive organs is taken up in class, the laboratory work is an experimental digestion of starches and proteids, in an "artificial stomach," formed of a zinc pan, with large meshed wire gauze over it, and filled with water kept at a constant temperature  $98\frac{1}{2}^{\circ}$  F. Into the meshes of the gauze can be slipped the test tubes holding the food and the various digestive ferments, and at the end of three or four hours of heating the apparatus is set away to be tested for the results of digestion on the following day. The process is essentially that outlined in Peabody's Laboratory Manual.

To avoid the tendency of science teaching to take the short cut from facts to generalization, the negative results as well as the

positive need consideration; and while experiments are made in digestion of proteids with pepsin and acid together, it is well to test whether either pepsin or acid alone would produce the same effect, and whether pepsin will digest other foods than proteids; or whether starch digests equally well at all temperatures.

For the study of cell structures and functions several days may be profitably spent on the paramoecium or amoeba, and the most important functions of the animal may be considered in the following order:

(1) Locomotion; (2) taking in of food; (3) digestion; (4) circulation; (5) assimilation; (6) taking in of oxygen; (7) oxidation of metabolism; (8) excretion; (9) sensation; (10) reproduction.

It is thought this will help in fixing the idea that physiology deals with units in action, each influencing the other. The circulation of the blood, for example, is not a fixed state, to be memorized, but is, at any given moment, an equilibrium resulting from the interaction of many shifting factors. Such factors must be severally known and the result of their interaction reasoned out. If the factors have not been acquired largely by personal observation, the mind will not grasp them with sufficient clearness to make possible their subsequent combination. For the most part physiology cannot be memorized but must be understood.

This part of the work often brings questions about bacteria and it is an easy way of introducing a little elementary bacteriology. A few test tubes if one has no Petri dishes, and any good nutrient medium, and it is easy to demonstrate the bacteria of dust, water, air, ice, milk, etc. This of course enters upon the field of diseases caused by bacteria, and the laboratory work is followed by a set of questions for which references are given, and which are finally talked over in class. These are rather wide in their range, including the use of feather dusters; susceptibility and immunity in disease; antitoxine; vaccination; flies and typhoid; mosquitoes and malaria; and special emphasis is placed upon tuberculosis, its prevention, and cure. Last spring this came at the time of the Anti-tuberculosis Society's exhibition in our city and we spent one class period in a very profitable study of that exhibit.

The remainder of the work follows more nearly the beaten track so far as the study of circulation, respiration, and excretion are

concerned. As we study the lungs we make records of the vital statistics of each pupil, finding age; height; weight; chest measurement in inspiration and expiration; lung capacity with a simple form of spirometer; relation of chest average to height; and of height and weight. Students take pride in a good lung record and often take pains to increase it, taking occasional measurements during the semester.

Before we begin the study of the nervous system this semester, the class will be given an illustration of reflex action in a brainless frog. We shall also see the nervous system and get some notion of nerves and ganglia and their functions. A dissected model is a great help in teaching the structure and functions of the brain.

It is quite possible that muscles and bones will form the last subjects we may touch upon. A very few laboratory periods spent on these subjects when the pupils are really desirous of knowing, and have got over their fussy notions, will settle their structure. As to muscular action, why should it be learned from a book when, as Huxley said long ago, "There is a very convenient and handy animal which everybody has at hand, and that is himself." A little experimental study of his biceps will tell a boy more than any book, and for that matter he has probably learned it without any book; and has only, to quote Huxley again, to realize that "Science is only trained and organized common-sense." The Harvard joint apparatus will interest him in a calculation of how much force he expends in his various motions.

Bones are more interesting to boys and girls if studied from the standpoint of comparative anatomy, and the study of the human body offers a fine chance to develop this side of the subject. If you can send them to a museum with a set of questions applicable to the bones of any vertebrate, you are likely to be furnished with subject matter for some time. It is usually possible to have a collection of skulls in the school, and teeth are vastly more interesting if compared in man, and in horse, cow, dog, and rat or squirrel.

I have left the subject of the teaching of alcohol and narcotics until the last, partly because I hesitate to take it up—my students come to me with a distaste for the whole subject of physiology, which I often find is acquired as the result of a grammar school experience of the subject, dealing with it only from the standpoint of temperance teaching. Perhaps the most successful

way in which we have ever dealt with this included the collection of a large set of statistics from the police courts of our city showing the total number of arrests, the proportion of those arrested for drunkenness and disorderly conduct, the whole cost of our police department; and the part of this expense due to drunkenness. In the same way we calculated the cost of caring for paupers, criminals, and insane due to drink; and finally the amount it cost each citizen because of this. It happened that the class was composed of pupils who had studied domestic science and shop work in the grades, but could not continue their study in the High School, because of lack of funds to establish and maintain a manual training addition. They made a few very startling applications of their own as to possible disposals of such a sum of money.

Everywhere and always, throughout the semester of physiology in laboratory and class room we try to demonstrate the connection of right living and health; the need of knowing what right living is, and under what conditions it is attained, and the danger of ignorance, not only to the individual, but to the family and the community. People who treat their bodies as they please, and transgress rules of personal hygiene of which they should have a definite understanding, are physical sinners, and unfortunately the results of the crime do not always visit them alone.

Public hygiene may be enforced but personal and domestic hygiene must be taught. No law can compel citizens in time of epidemic of typhoid to boil their drinking water, and cleanse food to be eaten without cooking, but persistent teaching will do much toward it. A grade teacher of my acquaintance found not long ago, as the result of an accidental question that only one child in her entire roomful ever had an open window in his bedroom at night.

General sanitary improvement is dependent upon the intelligence of the community, as well as upon efficient health officers, and one of the important duties of the physiology teacher is to disseminate more widely knowledge concerning public, domestic and personal hygiene.

Personal hygiene is applied physiology, and knowledge of the normal functions of the body and the simple methods of keeping them in healthy action, is the one thing no educated person should be excused from possessing. Yet most children reach maturity without sufficient parental or scholastic instruction in many essen-

tial matters of health. Men and women who would be greatly chagrined to be corrected in the pronunciation of a popular foreign proper name, or who would resent any suggestion as to their lack of general culture or learning, show not the slightest embarrassment at their ignorance of the common physiologic functions.

Said an exasperated physician on this point, "Not to know what each one owns would, in commercial life, be considered as either idiotic, or criminal negligence; and yet not one in ten can tell on which side of the body the liver is placed, while the vast majority complacently clasp their hands over some thirty feet of intestines when asked to locate the stomach, and of its structure, use, and care, they know even less."

Persons of intelligence continually furnish thoughtless recommendations of purely "quack" remedies, and unscientific instruments and apparatus, and allow their names and pictures to appear in periodicals—like those "eminent" clergymen who recommend "Peruna" with its 28.5 per cent by volume of alcohol; and its kindred spirits! A list of the common patent medicines with their percentages of alcohol is a good thing to put up for a class to read, and a discussion of their ingredients and the effects of them on the human body is a good thing for the pupils and indirectly for the parents.

We approach the subject of physiology by two paths; the direct, which I have outlined above; and the indirect in connection with the year's work in Zoology. This has its advantage in the fact that pupils are often wearied of the subject of Physiology in the elementary schools, and this gives an entirely new approach. There is also an advantage in that erroneous impressions gained from the elementary work are more likely to be corrected when the facts of human structure and function are approached from the animal standpoint, instead of from the familiar human aspect of elementary school physiology. The study of animals and plants gives the proper perspective for the biological study of man, making this vastly more interesting and intelligible. In this connection of course the comparative view prevails, emphasis is placed upon resemblances in structure and function between man and animals, resemblances to all living things; similarities to all vertebrates; resemblances and differences of man and other mammals.

Incidental references to human structure come up in connec-

tion with many lessons, but the formal comparative study is best taken up at the end of the course in Zoology, which will then have prepared for an intelligent appreciation of human physiology. This course is handicapped with us because Zoology precedes instead of follows Chemistry, whereas the reverse should be true. So long as any science which deals with living matter precedes Chemistry it must be hampered; for the study of life constitutes the Chemistry and physics of living matter

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**PERSONAL OBSERVATIONS OF THE TEACHING OF MATHEMATICS IN PRUSSIA.\***

BY HERBERT E. COBB,

*Professor of Mathematics, Lewis Institute, Chicago.*

When one speaks of Germany or of the German schools he has in mind usually Prussia or the Prussian schools. The reason for this is apparent when we compare Prussia with the other German states. The German empire has a population of 56,000,000. Prussia, 34,000,000; Bavaria, 6,000,000; Saxony, 4,000,000; while the other twenty-three states form only a small part of the empire. Prussia is the leader in the rapid advance along all lines in the empire.

To say that certain things are true of German schools is in many cases not an exact statement, since there are differences in the schools, not only between the several states but also between the different parts of the same state. There is no Minister of Education for the empire; though the general character and aims of the schools, and the training and duties of the teachers are the same throughout Germany. Another cause of difference in the schools is that while some of the states are largely Protestant others are largely Catholic; in Prussia the number of Protestants is to the number of Catholics as eleven to six, while in Bavaria the ratio is four to eleven. The greatest differences exist in the common school system. In Bavaria, for example, the common schools are the preparatory schools for all the higher schools, while in Prussia they are the schools for the lower classes, cut off entirely from the higher schools which have preparatory schools of their own. In 1902-3 the number of laborers' sons in the ten Prussian universities was

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\*From a paper read before the Mathematical Section of the Central Association of Science and Mathematics Teachers on Nov. 30, 1906, at the University of Chicago.

1.27 per cent of the total number of students; in seventy Gymnasien there were only eighteen sons of laborers or lower class servants.

There are so many points of interest which might be mentioned that it has been difficult to choose the topics to present in the few minutes at my disposal. The paper will deal rather informally with a few of the things one can learn only by a study of the schools at close range. Little will be said of the details of mathematics teaching, for this you will find in Dr. Young's *Teaching of Mathematics in Prussia*. It would take years of study to understand the school system of that country, since it is an integral part of the national life and cannot be understood except by a comprehensive study of the whole life of the nation. To illustrate, Dr. Young's book states that, "in the work in mathematics done in the nine years from the age of nine on, we Americans accomplish no more than the Prussians, while we give to this work about seven fourths times as large a fraction of the total time of instruction as do the Prussians." What are the reasons for this? A few of them are the following: First, the training of the teachers. Every teacher who has secured a permanent position in the higher schools must have completed the course of a nine year higher school, studied three years at the universities, the work during these three years corresponding in part to postgraduate work in America; he must have passed a severe examination; studied one year at a teachers' seminary; and finally taught one year under the direct oversight of an experienced teacher. Second, a course of study carefully prepared, and modified about once in ten years. This curriculum, prepared for all the higher schools in Prussia, fixes rather definitely the amount and manner of presentation of each subject. Third, pupils working as no body of pupils ever worked in America. In school they are driven on by the military spirit which prevails to a greater or less degree among the teachers, and at home the demands of the class system often make the parents hard taskmasters. The boy *must* complete six, seven, eight or nine years of school if he is to enter those occupations which social usages set apart for his class.

We in America are apt to think that the German is slow and unprogressive; and that his school system slowly developing through centuries is now perfect and immutable. It is surprising, however, to find how rapidly changes are taking place.

For the last twenty-five years there has been a bitter struggle for reform in the higher schools, and the reformers are winning the battles. Modern languages, mathematics, and the sciences are displacing Latin and Greek in the curricula, and the wonderful increase in the number of Realschulen and Reformschulen shows how fast the new ideas are advancing. As you may imagine the teachers of mathematics are alive to the situation which they have helped to create, and are planning reforms of their own. It is surprising to see how closely they are following the lines of reform along which we in America are working. Professor Klein and some of his colleagues in the University of Göttingen, are giving summer courses in mathematics to teachers, in which the reform ideas are emphasized. Committees appointed by associations of teachers and school authorities are at work all the time and text-books embodying the new ideas are published from time to time. Indeed, the new books of the last few years show how widespread is the feeling that the schools are not perfect; and they also show that a large body of teachers and school authorities are busily engaged in plans for improvement. The following list contains the names of a few of the books published during the last two or three years, which are especially valuable in helping one to understand the German school system:

#### GERMANY, THE GERMAN SCHOOL SYSTEM, MATHEMATICS.

##### GERMAN LIFE IN TOWN AND COUNTRY.

W. H. Dawson. pp. 268. Geo. Newnes, London. M. 3.60.

##### GERMAN DAILY LIFE.

Dr. R. Kron. pp. 344. Newson & Co. 1901. 75 cents.

##### KÜRSCHNERS JAHRBUCH.

pp. 462. M. 1.50. Post 25 pf.

##### DAS UNTERRICHTSWESEN IM DEUTSCHEN REICH.

W. Lexis. 1904. A. Asher & Co., Berlin. 4. Bände. M. 46.60.

Band I. Die Universitäten.

pp. 655. M. 11.20. Post M. 1.40.

Band II. Die höheren Lehranstalten und das Mädchenschulwesen.

pp. 426. M. 8.20. Post M. 1.40.

Band III. Das Volksschulwesen.

pp. 564. M. 10.20. Post M. 1.40.

Band IV. Das technische Unterrichtswesen.

1. Teil. Die Technischen Hochschulen.

pp. 303. M. 6.—. Post 50 pf.

2. Teil. Die Hochschulen für besondere Fachgebiete.

pp. 245. M. 5.—. Post 50 pf.

3. Teil. Das mittlere und niedere technische Unterrichtswesen.

pp. 291. M. 6.—. Post 50 pf.

- HISTORY AND ORGANIZATION OF PUBLIC EDUCATION IN THE GERMAN EMPIRE.  
W. Lexis. pp. 182. A. Asher & Co. 1904. M. 3,50. Post 30 pf.
- DIE REFORMBEWEGUNG AUF DEM GEBIETE DES PREUSSISCHEN GYMNASIAL-  
WESENS VON 1882—1901.  
Dr. A. Messer. pp. 173. Teubner. 1901. M. 3,20. Post 30 pf.
- DAS DEUTSCHE BILDUNGSWESEN.  
Dr. F. Paulsen. pp. 192. Teubner. 1906. M. 1,25. Post 20 pf.
- GESCHICHTE DES DEUTSCHEN SCHULWESENS.  
Dr. K. Knabe. pp. 150. Teubner. 1906. M. 1,25. Post 20 pf.
- DER DEUTSCHE UND SEINE SCHULE.  
Dr. L. Gurlitt. pp. 240. Wiegandt & Grieben. 1905. M. 3,—.  
Post 30 pf.
- DIE HÖHEREN SCHULEN IN PREUSSEN UND IHRE LEHRER.—Sammlung der  
wichtigsten, hierauf bezüglichen Gesetze, Verordnungen, Verfügungen  
und Erlasse.  
Adolfe Beier. pp. 250. Halle a. S., Waisenhaus. 1902. M. 9,—.  
Post M. 1,40.  
Ergänzungsheft I. (1902 bis Jan. 1904). M. 1,60. Post 20 pf.
- BEITRÄGE ZUR OBERLEHRERFRAGE.  
K. Fricke und F. Eulenburg. I. Die Geschichtliche Entwicklung des  
Lehramts an den höheren Schulen. II. Die soziale Lage der Oberlehrer.  
pp. 120. Teubner. 1903. M. 1,60. Post 20 pf.
- LEHRPLÄNE UND LEHRAUFGABEN FÜR DIE HÖHEREN SCHULEN IN PREUSSEN  
VON 1901.  
pp. 107. Halle a. S., Waisenhaus. M. 1,—. Post 20 pf.
- ENCYKLOPÄDIE DER ELEMENTAR-MATHEMATIK.  
Band I. Elementare Algebra und Analysis.  
pp. 447. 1903. M. 8,—. Post M. 1,40.  
Band II. Elementare Geometrie.  
pp. 600. 1905. M. 12,—. Post M. 1,40.  
Band III. Anwendung der Elementar-Mathematik. (Unter der Presse.)  
H. Weber und J. Wellstein. Teubner.
- MATHEMATISCHE UNTERHALTUNGEN UND SPIELE.  
W. Ahrens. pp. 428. Teubner. 1901. M. 10,—. Post M. 1,40.
- EIN MATHEMATISCHES HANDBUCH DER ALTEN AEGYPTER.  
A. Eisenlohr. pp. 278. J. C. Hinrich. 2 Aufl. 1891. M. 14,50.  
Post M. 1,40.
- SAMMLUNG GÖSCHEN. M. 0,80. Post 15 pf.  
Arithmetik und Algebra. Prof. Dr. H. Schubert.  
Ebene Geometrie. Prof. G. Mahler.  
Ebene und sphärische Trigonometrie. Dr. G. Hessenburg.  
Stereometrie. Dr. R. Glaser.  
Niedere Analysis. Dr. B. Sporer.  
Geometrisches Zeichnen. H. Becker.  
Geschichte der Mathematik. Dr. A. Sturm.
- DIE MATHEMATIK FÜR REALE ANSTALTEN UND REFORMSCHULEN.  
Teil I. Die Unterstufe.  
pp. 199. 3. Aufl. 1904. M. 2,20. Post 30 pf.  
Teil II. Die Oberstufe.  
Abt. 1. Planimetrie, Algebra, Trigonometrie und Stereometrie.  
pp. 223. 2. Aufl. 1902. M. 2,80. Post 30 pf.  
Dr. H. Müller. Teubner.
- LEHRBUCH DER ELEMENTAR-GEOMETRIE.  
Henrici und Treutlein. pp. 584. Teubner. 1897. M. 9,—. Post  
M. 1,40.

ZEITSCHRIFT FÜR MATHEMATISCHEN UND NATURWISSENSCHAFTLICHEN  
UNTERRICHT.

8 Hefte. M. 12,—. B. G. Teubner, Leipzig, Poststr. 3.

UNTERRICHTSBLÄTTER FÜR MATHEMATIK UND NATURWISSENSCHAFTEN.

6 Hefte. M. 3.60. Otto Salle, Berlin W. 30, Maafsenstr. 19.

These books or any book published in Germany may be ordered from:

DIE AKADEMISCHE BUCHHANDLUNG VON CONRAD SKOPNIK,

Prinz Louis Ferdinandstr. 1.

BERLIN NW. 7.

Germany.

GERMAN LIFE IN TOWN AND COUNTRY.—In English. Well written; interesting. It gives a good account of the social and political conditions, and the everyday life of the people of all classes.

GERMAN DAILY LIFE.—In German. It is a guide to the German life and customs, schools, the army, railroads, street cars, church, making calls and so on.

KÜBSCHNER'S YEARBOOK.—Something like the "Daily News Almanac."

THE SYSTEM OF INSTRUCTION IN THE GERMAN EMPIRE.—A very complete account of the history and organization of the school system. It was prepared by a large number of educators for the World's Fair at St. Louis.

HISTORY AND ORGANIZATION OF PUBLIC EDUCATION IN THE GERMAN EMPIRE.—In English. An abridgement of the last-mentioned work. It is a good brief account of the schools and universities; it contains many statistical tables.

THE REFORM MOVEMENT IN THE DOMAIN OF THE PRUSSIAN GYMNASIAL SYSTEM.—This book shows how strongly the conservatives have opposed any decrease in the study of Latin and Greek, and how fiercely the battle for reform has been waged.

THE GERMAN EDUCATIONAL SYSTEM.—An excellent short history of the development of the schools from 600 A. D. Dr. Paulson is professor of philosophy in the University of Berlin, and is an authority on educational questions.

HISTORY OF THE GERMAN SCHOOL SYSTEM.—This covers the ground of the last-mentioned book, but supplements it admirably as the subject is treated from a different point of view.

THE GERMAN AND HIS SCHOOL.—Notwithstanding the vigorous way in which the author says disagreeable things, there is much truth in this book. A few quotations will give an idea of the style. "The consequence is that our Gymnasien more and more are producing only subordinate state officials, office men who observe punctually their office hours, and ask obediently the opinion of their all-knowing superior officials." "There is altogether too much which our boys in the higher schools must master merely by memorizing. They suffer from hypertrophy of the brain." "Every man has—God be thanked—his own head, but the school knows nothing of this, absolutely nothing, although it has been dealing with men's heads for centuries, and in doing this only, has allowed their bodies to become stunted. No, not with the whole head only with the 'thought box' not with the senses, the eyes and ears, the smell and taste. The school thinks that it must fill up each head with the same things, and demands from each head that it answers exactly in the same way, like an echo. Clear up to the ninth year all learn the same things, the same Bible history, poems, rules, laws of speech, mathematical formulas, odes of Horace, lines of Vergil; the same yard measure is applied to each head; each head

is expected to have the same power of memory. Whoever fails at his task is considered a lazy-bones or a blockhead, receives low marks, is not promoted at school and at home is looked at askance, and has accordingly a sad time in his youth. Therefore, O man, if you are born in Germany, and wish to live there, be solicitous first of all for a good head for learning. Honesty, strength of character, pluck, shrewdness, good nature, piety, artistic power—everything, everything which does not come in question at once, which one cannot perchance use when taking the final examination of the school is considered of less value than 'learning by heart.'"

**THE HIGHER SCHOOLS IN PRUSSIA AND THEIR TEACHERS.**—A collection of the most important rules and regulations. Forty-five pages of this book are devoted to the regulations concerning the final examinations. The minutest details are provided for. Each year the title of professor is conferred on one third of those teachers who have taught seventeen years. Last spring there appeared in a Berlin daily paper a rather pathetic letter from a teacher in a higher school who was evidently a candidate for this title. He complained quite bitterly that the statistics of two years ago were made the basis of giving the title this year, and it was not fair as it would not permit the proper number of teachers to receive the title. He closed by saying that the teachers have enough cause of complaint against the government without being annoyed by such little pin-pricks as this.

**CONTRIBUTIONS TO QUESTIONS CONCERNING THE TEACHERS IN THE HIGHER SCHOOLS.**—Two essays. The first discusses the hardships that these teachers endure; the second gives a good account of the social position of the teachers.

**CURRICULA AND INSTRUCTIONS TO TEACHERS, FOR THE HIGHER SCHOOLS IN PRUSSIA.**—This book gives the courses of study, and directions to the teachers in presenting the subjects.

**ENCYCLOPEDIA OF ELEMENTARY MATHEMATICS.**—Excellent reference books, though not very elementary.

**MATHEMATICAL CONVERSATIONS AND PLAYS.**—A good collection of mathematical puzzles and so on.

**A MATHEMATICAL HANDBOOK OF THE OLD EGYPTIANS.**—A translation into German of Ahmes' "Directions for Knowing All Dark Things."

**SAMMLUNG GÖSCHEN.**—These little books are excellent for pupils in mathematics who are studying German. They are simple and elementary and contain many interesting problems.

**DIE MATHEMATIK FÜR REALE ANSTALTEN UND REFORMSCHULEN.**—Text-books used in the schools.

The two journals mentioned are among the best of the many journals published for teachers.

## HOME-MADE OR INEXPENSIVE MATHEMATICAL APPARATUS.

BY JOSEPH V. COLLINS.

*State Normal School, Stevens Point, Wis.*

Looking over the files of SCHOOL SCIENCE AND MATHEMATICS one finds descriptions of quite a variety of mathematical apparatus available for use in the school room. Thus there have been described:

1. Donecker's Algebraical Balance (patented), page 411, June '05.
2. Lennes' form of Algebraical Balance, page 602, Nov. 1905.
3. Bass's Plane Table and accompanying apparatus, page 207, Mar. '04.
4. Comstock's Solid Geometry Modeling Frame, page 171, Jan. '04.
5. Porter's Compositions of Motions, page 45, Jan. '05.
6. Holtz's Parallelogram of Forces, page 191, March '05.

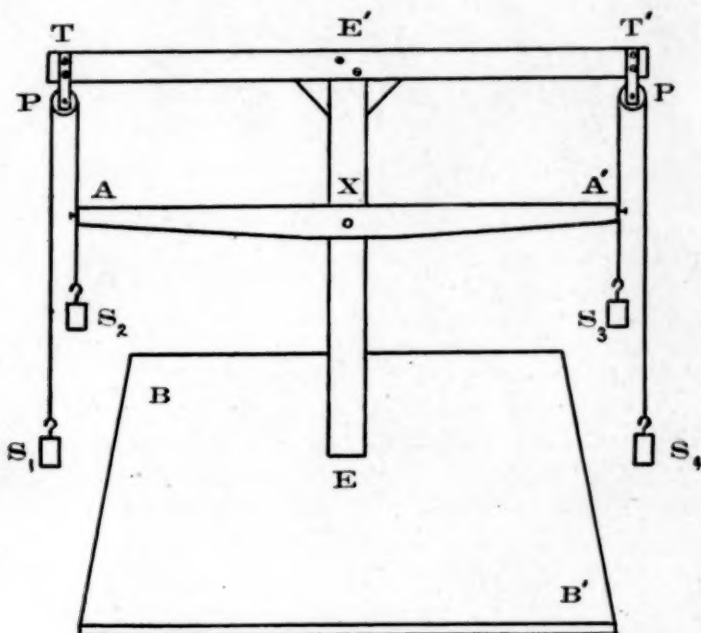
and possibly other forms which have been overlooked.

It is the purpose here to describe some very simple forms of the apparatus mentioned and to call attention to still other instruments which can be readily constructed and turned to practical use in mathematics teaching. The equipment of mathematical apparatus for a secondary school might well include: An equation balance, a solid geometry modeling frame, a plane table, pantograph, compass-protractor, diagonal scale, slide-rule, set of regular polyhedrons, oblique paralleliped cut by plane through diagonally opposite edges, symmetrical triedral angles, set of circular discs for computing values of  $\pi$  from measurements, abacus; all this in addition to the customary blocks and blackboard sphere. If a school have a Manual Training Department, all except the sphere can be made by the pupils, the making of the apparatus adding greatly to its value to the maker. Brief descriptions of apparatus which needs explanation follows.

### 1. *An Algebraical Balance.*

Let  $BB'$  be the base of the balance, a board 15x9 inches;  $EE'$  a vertical post mortised from a point  $E$  a little back of the center of  $BB'$ ;  $TT'$  a cross-bar 15 in. long fastened at  $E'$ ;  $P, P'$  frictionless pulleys  $3/2$  in. in diameter;  $A, A'$  arms of a balance whose axis is at  $X$ ;  $S_1, S_2, S_3, S_4$  scale pans made of tin. The scale pans  $S_1$  and  $S_2$  descend below  $BB'$  (which is made to rest on books) to avoid colliding with the other two. Weights are sticks of crayon.

Three claims can be made for this form of the balance; (1) It works, and does not get out of order. (2) It is very inexpensive (especially if the pulleys are borrowed from the physical laboratory). (3) The pulleys, reversing the direction of gravity, harmonize well with the idea of negative scale pans. For uses to which the balance can be put, consult the articles referred to.

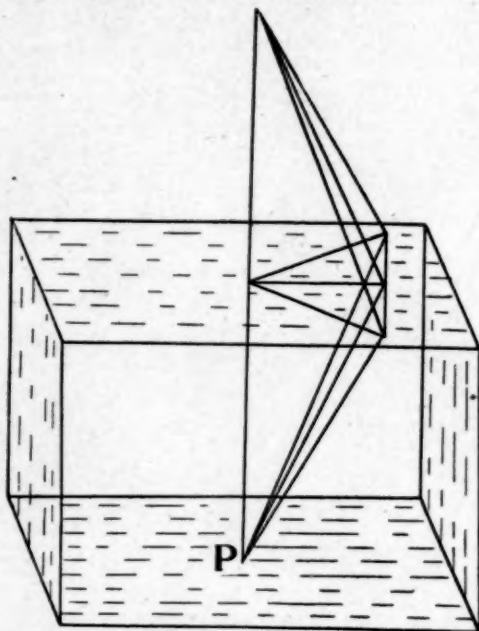


## 2. Solid Geometry Modeling Frame.

Take an ink box, 12"x9"x7", and knock the bottom out. With a  $\frac{1}{8}$  in. bit bore holes through one side of the box at the vertices of various polygons, triangles, square, rhomb, and regular hexagon. Holes should also be bored obliquely for a triangle and a rhomb. Cut off now a number of pieces of straight steel wire  $\frac{1}{10}$  in. in diameter and 18 in. long. The figure, over the page, shows the apparatus arranged for a well known proposition in solid geometry. A loop is made in the top end of wire and a picture hook P is screwed obliquely in the lower base to hold the wire in place and to hold the string which passes through the holes in the manner indicated.

This apparatus can be adapted for proving a surprisingly large number of the propositions of solid geometry. It should

not, of course, be used when the student is able to get along without it. When used, it gives the real thing. One use to which it can be put is to let 7 wires be the edges and axis of an hexagonal prism. Then by employing a string, giving it one turn around each wire, the base structure of a honeycomb can be very clearly represented. An excellent exercise is to use this apparatus to follow the description of a comb given in the Britannica article on bees, or in such a book as Maeterlinck's work on bees. The apparatus can be used also for representing the different type forms in Crystallography.



An interesting and very convenient form of modeling frame now on the market is that advertised in the columns of SCHOOL SCIENCE AND MATHEMATICS by the Randolph Jones Mfg. Co., 361 Mohawk Street, Chicago.

### 3. *Plane Table.*

A large squared board or table,  $2\frac{1}{2} \times 2\frac{1}{2}$  ft., mounted on any form of tripod, with any alidade of the simplest form of construction, like the sights of the old surveyor's compass, can be used for plane table work. Pacing can replace stadia measurements.

### 4. *Pantograph.*

A simple pantograph can readily be constructed of wooden

strips and thin wire nails, or it can be purchased for a nominal sum. Pantographs can be had as low as 20 cents. Once made the instrument can be used to trace all kinds of similar polygons and figures. The pantograph furnishes two or three interesting propositions: (1) To prove that the fixed point and the two tracers once in line remain collinear. (2) That if one tracer moves on a straight line, the other does also. (3) That the two polygons traced are similar and have for ratio of similitude the constant ratio of the pantograph.

#### 5. *Blackboard Compass-Protractor.*

A blackboard compass can be made in the usual form but of square cross section throughout ( $9/16$  in.) with inches marked on it for use as a scale. The head being made exactly semi-circular, a  $9/10$  vernier can be constructed on it which will enable the user to set it to any angular number of degrees desired. Thus the instrument in a form as convenient as a 30 in. ruler can be used either as a rule to draw lines, a scale to measure distances, a compass to draw circles, or a protractor to set off angles. A  $5/16$  in. hole should be bored in the end of one leg and a slit sawed, thus admitting of the convenient insertion and removal of crayon, and a rubber from a penny pencil inserted in the end of the other leg to act as a pivot. A diagonal scale can be drawn on the blackboard or on heavy cardboard for use with the compass.

#### 6. *Slide Rules.*

Slide rules should first be made by students using a log table. Then accurately made paper scales should be purchased and mounted by students. Besides these inexpensive ones schools should possess at least one good instrument.

The other forms of apparatus mentioned above need no further comment here. As will no doubt be inferred the apparatus and exercises just described have been actually made and used. The apparatus is not the product of a trained workman but of one who has mastered no more tools than the hammer, saw, and square. Doubtless there are many teachers not themselves mechanically inclined who will prefer to purchase the patented articles. The writer is not disposed to let this opportunity pass to commend the editor of *SCHOOL SCIENCE AND MATHEMATICS* for the attention he has given to mathematical apparatus. Concrete aids are very much more likely to stimulate to better teaching than abstract suggestions.

It is interesting in connection with the present subject to turn to the "Katalog" of models, apparatus, and instruments of the German Mathematical Society, edited by Walther Dyck, and to see the bewildering variety of mathematical apparatus that has been devised and put to use. Thus we find (omitting many topics entirely) historical apparatus for the generation of various curves, such as the conchoid of Nicomedes; the planimeters for mechanical integration (18 kinds); instruments for harmonic analysis; slide rules (22 kinds); adding machines; calculating machines (6 models); apparatus for solving (1) simple simultaneous equations, (2) cubic equations, (3) higher equations; line division apparatus; pantographs; models for elementary geometry instruction; models for groups of transformations; thread and other models of all kinds of surfaces; apparatus for explaining mechanical laws of all kinds; models for crystallography; etc., etc. The list of models for instruction in elementary geometry and trigonometry includes: models of elementary line forms; forms for illustrating propositions concerning angles in triangles, quadrilaterals, polygons; forms for propositions concerning congruence, similarity, areas, and the circle. In solid geometry models for showing the rotation of bodies, the illustration of the propositions relating to the straight line and plane in space, and those for solid angles; 12 constructions of the simplest geometrical bodies, as the pyramid, parallelopiped, etc.; model showing triangular prisms made up of pyramids, etc.

The largest number of the models, however, deals with instruction in higher mathematics. Two of these are interesting for the names they bear, if for nothing else. They are, No. 84 *Praecisionsgefaellmessapparat*, and No. 282 *Modell der Wellengeschwindigkeitsflaeche*. An article in the *Britannica* under the title *Mathematical Drawing and Modeling* tells how the complex constructions used as aids in higher mathematics are made.

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When you have trouble with your air-pump leaking between the plate and bell-jar, try placing on the plate a sheet of rubber of good thickness, making a seal with water. *Do not use oil.* You will be delighted with the results.

# FACTORING THE TYPE $px^2+qx+r$ .

BY DAVID EUGENE SMITH, LL.D.,

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I have been interested in reading Mr. Toan's article, with the above title, in the April number of *SCHOOL SCIENCE AND MATHEMATICS*, in which he gives what I have always found to be the most practical method of attacking the quadratic trinomial. I am even more interested, however, in the note on p. 292, giving the impression that this method was not published before 1906. As a matter of fact it was published, I believe for the first time in America, in my *Teaching of Elementary Mathematics* (1900), and, in a text-book, in the *Elements of Algebra* written by Professor Beman and myself in 1900. I first saw it in a little English work on factoring, published some years before. Since 1900 it has been used by a large number of teachers in this country, and always, I think, with good results. Of course this question of precedence is of little moment, the great desideratum being that the method should be known. For this reason Mr. Toan should be thanked for assisting in this movement.

There is, however, another method, not suited to the high school, but very interesting from the mathematical standpoint, which deserves to be known to teachers. It was first suggested, I think, by Dr. Di Dia in *Il Pitagora* (Palermo, vol. IX, p. 11) in 1902. The point at which he aims is to deduce a formula for factoring this type just as we have one for writing down the roots of a quadratic or cubic equation.

This he does as follows:

$$\begin{aligned} ax^2+bx+c &= \frac{4a^2x^2-4abx+4ac+b^2-b^2}{4a} \\ &= \frac{(2ax+b)^2 - (b^2-4ac)}{4a} \\ &= \frac{(2ax+b+\sqrt{b^2-4ac})(2ax+b-\sqrt{b^2-4ac})}{4a} \end{aligned}$$

The result is easily remembered, since the first factor of the numerator is  $f'(x)$  + the square root of the discriminant, and the second factor is its conjugate. Thus to factor  $6x^2+11x-10$  we have  $f'(x)=12x+11$ .

$$\text{Discriminant} = b^2-4ac=121+240=361=19^2.$$

$$\begin{aligned} \therefore 6x^2+11x-10 &= \frac{(12x+11+19)(12x+11-19)}{4 \times 6} \\ &= \frac{(12x+30)(12x-8)}{4 \times 6} = (2x+5)(3x-2) \end{aligned}$$

Of course the great value of such a formula is seen when the factors contain numbers of some size, as in the case of  $(27x+625)(125x+108)$ .

## PROBLEM DEPARTMENT.

IRA M. DELONG,

*University of Colorado, Boulder, Colo.*

*Readers of the Magazine are invited to send solutions of the problems in this department and also to propose problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to Ira M. DeLong, Boulder, Colo.*

## ALGEBRA.

58. *Proposed by H. C. Whitaker, Ph.D., Philadelphia, Pa.*

The money that will pay the wages of Tom Jones for  $61\frac{1}{4}$  days will pay the wages of Harry Smith for  $81\frac{2}{3}$  days. For how many days will the same sum pay the wages of the two men?

*Solution by T. M. Blakslee, Ph.D., Ames, Iowa.*

Let  $s$  = the amount of money, (any unit).

$x$  = daily wage of T. J. =  $s/61\frac{1}{4}$ ,

$y$  = daily wage of H. S =  $s/81\frac{2}{3}$ ,

Required time =  $s/(x+y) = 35$ .

Generalized: If the money pays  $A$ 's wages  $a$  days and  $B$ 's wages  $b$  days, it will pay the wages of both  $ab/(a+b)$  days.

59. *Proposed by H. C. Whitaker, Ph.D., Philadelphia, Pa.*

At a certain time a train overtakes a man and ten seconds thereafter passes him. Twenty minutes after passing this man, the train meets another man and in nine seconds thereafter passes the second man. Counting from the time that the train passed the second man, how soon will the two men meet?

*Solution by E. Kesner, Salida, Colo.*

Let  $x$  = no. of ft. train runs in a second.

$y$  = no. of ft. first man walks in a second.

$z$  = no. of ft. second man walks in a second.

$l$  = length of train.

Then

$$10(x-y) = l, \dots, (1)$$

$$9(x+z) = l, \dots, (2)$$

$$\text{and required time} = \frac{1200(x-y) + l - 9(y+z)}{y+z} \dots (3)$$

$$\text{From (1) and (2) } x = 10y + 9z$$

$$l = 90y + 90z$$

Substituting in (3) and reducing gives 10881 seconds, or 3 hr. 1 min. 21 sec.

[NOTE—1° A form equivalent to (3), for the time, can be deduced in the following simple manner. Since 1209 seconds elapse between the instants the rear of the train passes the two men, the distance is  $1209(x-y)$  and the required time must therefore be  $\frac{1209(x-y)}{y+z}$

2° It is interesting to note that if both men are going in the same direction as the train the answer is unchanged.—ED.]

## GEOMETRY.

49. *Proposed by Byron E. Toan, Boulder, Mont.*

In a circle, radius  $R$ , given an arc of 45 degrees. To find the radius of a circle passing through the extremities of the given arc and having the area common to the two circles equal to  $\frac{2}{5}$  of the area of the required circle.

*Remark by H. E. Trefethen, Kent's Hill, Maine.*

The first sentence of Solution I should read:—the center of the required circle will be outside the given circle. For it is to be noted that the problem reads " $\frac{2}{5}$  of the *required* circle" and not  $\frac{2}{5}$  of *either* circle. There is but one solution to the problem as stated. If the problem had been  $\frac{2}{5}$  of the *given* circle, then the center of the required circle would be within the given circle as in solution II.

60. *Proposed by I. L. Winckler, Cleveland, O.*

Find a point in a given straight line from which, if tangents are drawn to two given circles, they will make equal angles with the given line. (From Chauvenet's Geometry.)

*Solution by H. E. Trefethen, Kent's Hill, Maine.*

Let  $mn$  be the given line and the given circles have their centers at  $A$  and  $B$ . From  $A$  draw  $AA'$  perpendicular to  $mn$  at  $C$ , making  $A'C = AC$ . About  $A'$  as center draw circle  $A' = \text{circle } A$ . In like manner draw circle  $B' = B$ . Then  $mn$  will be an axis of symmetry with respect to the equal circles, and the two lines drawn from any point in  $mn$  to corresponding points in the equal circles will be equal and will make equal angles with  $mn$ . There are two cases.

Case I. If the centers  $A$  and  $B$  of the given circles are on the same side of  $mn$ , draw the tangents common to each pair of diagonal circles  $AA'$  and  $A'B'$ . Each pair of symmetrical tangents intersect on  $mn$ , make equal angles with  $mn$ , and thus meet the conditions of the problem. Hence if the diagonal circles are wholly exterior to each other, there are four such pairs of tangents; if they touch externally, there are three such pairs; if they intersect, two pairs; if tangent internally, one pair; if one is wholly within the other, there is no solution. Among the tangents thus defined are included any that may be parallel to  $mn$ , though they do not meet  $mn$  at any finite distance.

Case II. If the centers  $A$  and  $B$  are on opposite sides of  $mn$  then draw the tangents common to the two circles on each side of  $mn$  etc.

61. *Proposed by Russell P. Harker, Parker, Ind.*

Given the base  $2b$  of a triangle and  $a$  the difference of the base angles. Find the equation of the locus of the vertex. (From Bailey and Wood's Analytic Geometry.)

*Solution by H. C. Whitaker, Ph.D., Philadelphia, Pa.*

Take the origin through the middle point of the given line AC; then  
 $\cot A = \frac{b+x}{y}$  and  $\cot C = \frac{b-x}{y}$ ;  $\cot (C-A) = \cot a = \frac{b^2-x^2+y^2}{2xy}$ .

Hence the equation is  $x^2-y^2+2xy \cot a = b^2$ .

### MISCELLANEOUS.

62. *Proposed by John W. Scoville, Syracuse, N. Y.*

A prison consists of 36 cells arranged like the squares of a chess board. There are doors between all adjoining cells. A prisoner in one of the corner cells is told that he can have his freedom, if he can get into the diagonally opposite corner cell, by passing through each of the cells once and only once. Can the prisoner win his freedom?

*Solution by I. L. Winckler, Cleveland, Ohio.*

Suppose the cells be numbered from one corner, starting in the first row from left to right and continuing in order in the second row from right to left and so on until all the squares are numbered. The prisoner must go from cell No. 1 to cell No. 31. He must enter 35 cells, and must always pass from an odd numbered cell to an even numbered cell and from an even numbered cell to an odd numbered cell. Suppose the moves he makes from cell to cell to be numbered. His move from an even numbered cell to an odd numbered one is an even numbered move. To move into cell No. 31 requires 35 moves from the start. Therefore he cannot escape.

*Statement by E. L. Brown, M.A., Denver, Colo.*

The prisoner can not win his freedom. He could, however, if the problem read as follows: A prison consists of 36 cells arranged like the squares of the *same color* of a chess board, there being six rows, each row having six cells. There are doors between all adjoining cells. A prisoner in the upper left hand cell is told that he can have his freedom, if he can get into cell No. 36, by passing through each of the *doors* once and only once.

The problem, as modified, comes under the theory of "Unicursal Curves."

### CREDIT FOR SOLUTIONS RECEIVED.

Algebra 48. M. L. Constable.

Algebra 53. Clyde W. Emmons, John W. Scoville.

Algebra 58. E. Kesner, E. C. Briggs, Helen Hanks, May Hanks, Clem Newton, Sidney Shonyo, Ernest Crutcher, Otto Lines, Alfred Kerndt, Louis England, Geo. Griswold, Jas. Beggs, Neva Charles, Harvey Charles, Irma Brewster, Bert Tomlin, Everett Lippard, Jessie Marvin, T. M. Blakslee, G. F. McAllister, J. B. Faught, Wm. B. Borgers, Emma Hyde, W. T. Brewer, H. C. Whitaker, I. L. Winckler, Walter H. Wood, M. L. Constable, John P. Clark, H. E. Trefethen, S. R. Scholes.

Algebra 59. Walter H. Wood, H. C. Whitaker, I. L. Winckler, W. T. Brewer, H. E. Trefethen, E. Kesner, Clem A. Newton, S. R. Scholes. Two incorrect solutions were received.

Geometry 54. John W. Scoville.

Geometry 55. A. Silverman.

Geometry 60. H. E. Trefethen, A. R. Maxson, I. L. Winckler, Walter H. Wood, E. L. Brown.

Geometry 61. H. C. Whitaker, H. E. Trefethen (2 solutions), I. L. Winckler, E. Kesner, A. R. Maxson, J. B. Faught, E. L. Brown. One incorrect solution was received.

Applied Mathematics 56. S. E. Kelsey.

Miscellaneous 62. E. L. Brown, John W. Scoville, I. L. Winckler, S. R. Scholes.

Total number of solutions, 65.

### PROBLEMS FOR SOLUTION.

#### ALGEBRA.

67. *Proposed by H. E. Trefethen, Kent's Hill, Maine.*

Solve for  $x$  and  $y$  the equations,

$$x + \frac{x^2}{y} + y = a.$$

$$x^2 + \frac{x^4}{y^2} + y^2 = b.$$

68. *Proposed by R. Boyle, Portland, Oregon.*

An army column is 25 miles long and it marched 25 miles. At the same time that the column started to march a courier started and rode forward to the head of the army, then immediately returned to the rear when he found that the rear was occupying the same ground as that occupied by the head of the army at the beginning of the march. Find how many miles the courier traveled.

#### GEOMETRY.

69. *Proposed by H. H. Wright, New York, N. Y.*

Two triangles are equal if the base, the opposite angle and its bisector of one are respectively equal to the base, opposite angle and its bisector of the other.

70. *Proposed by I. E. Kline, Blairstown, N. J.*

A horse is tied to a stake at the edge of a circular pond. The radius of the pond is 200 ft. and has no fence around it. How long must the rope be so that the horse may graze over one acre?

#### TRIGONOMETRY.

71. *Proposed by E. L. Brown, M.A., Denver, Colo.*

From the vertices of a triangular field whose sides are  $a$ ,  $b$ ,  $c$ , the angles of elevation to the top of a perpendicular tower are observed to be  $\alpha$ ,  $\beta$ ,  $\gamma$ , respectively. Required the height of the tower.

## DEPARTMENT OF SCIENCE QUESTIONS.

FRANKLIN T. JONES,

*University School, Cleveland, O.*

*This department is designed to serve as a medium for the exchange of ideas on questions and questioning in the sciences. Questions will be printed from various sources—college entrance examinations, textbooks, etc., etc. Comment is invited. Suggestions and criticisms as to character, adaptability, and usefulness are desired. Readers of this journal are invited to propose questions and problems which will be of general interest, or of a type which will be useful in the class-room. It is not expected that questions which will not be useful to pupils will be frequently printed.*

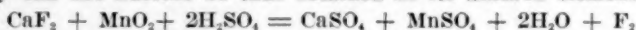
*Since the majority of the questions will be of a comparatively simple character, solutions and answers will not be published unless specifically asked for. Teaching suggestions are wanted.*

*Address all communications to the editor of the department.*

The following questions among others have been proposed. On account of the summary mentioned below some are postponed to be printed in a later number.

21. J. L. Riley, Jonesboro, Ark.

Why can not fluorine be thus obtained as its kindred elements are?



22. John J. Farrell, South Norwalk, Conn.

To what height would a person have to rise above the earth's surface to observe its revolutions, providing it was possible to remain stationary and to see so far? (Answers are desired.)

23. A. Haven Smith, Sioux City, Iowa.

Explain by the aid of a diagram how a cat-boat is sailed into the wind.

24. J. H. Clo, Pullman, Washington.

Why does the water in hot-water pipes freeze sooner than in cold-water pipes, both being at the same temperature? (Answers are desired.)

In view of the present discussion concerning the physics course and the proposed physics syllabus the editor has compiled some statistics concerning questions that have been asked by representative examining bodies since 1900. The numbers which follow were found in a careful attempt to classify topics covered by the college entrance examiners. It is evident that no two persons would be likely to classify in just the same way. Where a single question touched on more than one topic, it was classified under both. The examinations considered were College Entrance Examination Board, 1901, '03-'06; Case School of Applied Science, '03-'06; Cornell, '04-'06; Harvard, '01-'06; Massachusetts Institute of Technology, '04-'06; Princeton, June, '00, '02-'06; September, '05-'06; Sheffield Scientific School, '00-'06.

	BOARD	CASE	CORNELL	HARVARD	M. I. T.	PRINCETON	SHEPHERD	TOTAL
Mass and Weight .....					2	1		1
Center of Gravity, Equilibrium .....					3	3		5
Forces, Newton's Second Law .....	4	1		2	1	2	3	11
Moments of force .....	1	1	1	3	3	1	2	12
Parallelogram of Forces or Motions .....					1	2		3
Friction .....		1			1		2	4
Centrifugal Force .....	7	5	2	11	5	7	1	38
Archimedes' Principle, Flotation, Specific Gravity .....	1			1	2	1		5
Boyle's Law .....								
Pascal's Law, Air Pressure, Barometer, Siphon, Hydraulic Press, Balancing Columns .....	1			6	4	5		16
Pumps .....	2	1		2	2	2		7
Uniformly Accelerated Motion, Newton's First Law .....		5		2	2	2		11
Gravitation, Falling Bodies .....			1		5	4	3	19
Pendulum .....				2	2	2	1	6
Momentum, Newton's Third Law .....		2			2	1		5
Laws of Motion .....	8	3	1	6	5	6	6	30
Work and Energy .....		2			2	2	1	5
Horse-power .....				3	2	3	1	11
Simple Machines .....	1							1
Simple Harmonic Motion .....			1			2		3
Breaking Strength of Beams, Elasticity .....				1				1
Osmosis .....	2			2		1	1	6
Capillarity, Surface Tension .....	2	2			2	3	1	10
Definitions on Mechanics .....								2
States of Matter .....			3	5		4	3	12
General Knowledge, Common Sense .....		1		1	1	2	2	8
Wave Motion .....		4				2		6
Sound, Definitions .....		1	1			1	1	5
Laws of Strings .....				2		1	2	5
Organ Pipes .....				2				2
Resonance .....		2		1		3	1	7
Transmission of Sound .....	1		1	2	1	6	2	13
Velocity .....	4				1	2	2	9
Intensity .....	4	4	1		1	4	3	17
Pitch, Tension, Frequency, Wave-length, Temperature Quality .....	1	2			1	1		6
Manometric Flame, Chladni's Figures .....			2					2
Musical Scale .....			1			2	1	4
Interference, Beats .....		1				4	2	7
Doppler's Principle .....	1		1					2
Phonograph .....	1							1
Thermometry .....		1		2	2	3		9
Conduction, Convection, Radiation, Steam Heating .....	2	1	1	6	1	2	1	14
Latent Heat, Mixtures, Laws of Boiling, of Melting .....	4	2	2	4	6	12	1	36
Specific Heat .....	1	2	1	3	1	4	6	13
Expansion .....	2	1		3	1			8
Law of Charles .....				3		2	1	6
Laws of Boyle and Charles Combined .....						1		1
Humidity, Dew-point .....						3		3
Cooling Refrigeration .....			1	3		1	1	5
Heat, Work and Energy .....			1			5	4	10
Steam Engine .....				1	2	2	3	8
Magnetism, and Induction of .....	2					2	3	7
Electromagnetism, Field about Wire, Galvanometer, Bell, Induction Coil .....	5		2	2	4	6	5	24
Electrostatics, Leyden Jar, Electroscope, Induction .....		2	1	5	4	4	6	22
Battery, Polarization .....				2	2	1		5
Storage Cells .....				2			2	4
Methods of Producing Current .....					1	2	3	6
Induced Currents .....		3						3
Thermoelectric Currents .....			3	1				4
Measurement of Current, and E. M. F. .....							1	1
Motor, Dynamo, Series and Shunt Winding .....	3		1	1		3	1	6
Electrolysis .....								4
Resistance, Laws of; Cells in Series and Parallel, Shunts, Ohm's Law .....	3	2		6	4	6	2	23
Resistance, Measurement of, Wheatstone's Bridge .....		2	2			1	1	6
Electricity, Work and Heat, Watts .....	1			2	1	5	1	10
Telegraph .....		1		2		1		4
Telephone .....			1	1			2	4
Wireless Telegraphy .....				1				1
Historical .....							1	1

Definition—Units.....				1		2		3
Photometry.....	1			2		2		5
Shadows.....				1				1
Velocity of Light.....				1			1	2
Camera Obscura.....				2				2
Reflection, Concave Mirror, Images.....	2	3	1	4	4	3		21
Total Reflection, Critical Angle.....					1	2		3
Images by Lenses.....	3	2	2	9	3	4	2	25
Conjugate Foci, Magnification, Camera.....	1			1				2
Refraction, Deviation.....		5	1	1	3	6	2	18
Colors.....		1		1				2
Spectrum, Dispersion, Spectroscope.....			1	3	1	2	3	10
Spectacles.....				2		1	1	4
TOTALS.....	69	66	33	142	93	172	104	679

In the month of June practically every high school and academy in the country holds examinations. Teachers will confer a great favor upon the editor if they will send to him copies of all examination papers in the sciences used at this time. Extracts will be published next fall.

### A NOTE.

The following is so simple that I presume it is the possession of everybody, if so—to the waste basket!

Let  $o$  = any odd number

Put  $o^2 = 2x+1$  (1)

add  $x^2$ ,  $o^2 + x^2 = x^2 + 2x + 1$   
 $= (x+1)^2$

Which is the condition that  $o$ ,  $x$ , and  $(x+1)$  are sides of a right triangle.

Therefore (1) gives the right triangle whose sides are integers.

Simply substitute any odd number, except 1, for  $o$ , and solve for  $x$  and  $(x+1)$  and get a right triangle whose sides are  $x$ ,  $x+1$ , and  $o$ .

Many times in teaching elementary Mathematics, especially in Geometry and Trigonometry, I have found it desirable to give for supplementary work a varied list of easy right triangles. This gives any number of such triangles.

S. L. MACDONALD, Fort Collins, Colo.

### AN APPLICATION OF GROUP THEORY.

T. M. BLAKSLEE,

Ames, Iowa.

Professor Miller's article in the December number of *SCHOOL SCIENCE AND MATHEMATICS* suggests that an application that I began making in 1898 might be of interest.

If  $r_1, r_2, \dots$  are the roots of an equation, we will call the equation having the roots  $1/r_1, 1/r_2, \dots$  the reciprocal equation of this. I call the equation having the roots  $1-r_1, 1-r_2, \dots$  the unit-complement or complemental equation of the first from which it is obtained by diminishing the roots by 1, then changing their signs. Ex. Form equation (1) having the roots 2, 3, 4. Find the reciprocal equation (2) from (1). Find the complemental equation (3) from (2). Then the reciprocal and complemental alternately till (7). This will be found to be the same as (1). By varying the roots assigned, a large class is easily drilled in four of the important operations in the theory of equations. The equations for the above are:

$$\begin{aligned}
 x^3 - 9x^2 + 26x - 24 = 0 & \quad (1) \quad 24y^3 - 26y^2 + 9y - 1 = 0 & \quad (2) \quad 24z^3 - 46z^2 + 29z - 6 = 0 & \quad (3) \\
 6u^3 - 29u^2 + 46u - 24 = 0 & \quad (4) \quad 6v^3 - 11v^2 + 6v + 1 = 0 & \quad (5) \quad w^3 + 6w^2 + 11w + 6 = 0 & \quad (6) \\
 t^3 - 9t^2 + 26t - 24 = 0 & \quad (7).
 \end{aligned}$$

## COMMENTS ON MR. CAVANAGH'S ARTICLE.

Editor SCHOOL SCIENCE AND MATHEMATICS:

May I venture to offer some comments on Mr. Cavanagh's article on Optics, in the April number?

There is no doubt that the pupil's ideas concerning light will be very imperfect after a few weeks' study of the topic by any method, and by giving it more time we can make some of those ideas more definite and nearer to the truth. But we are obliged to draw the line somewhere: with all that we can tell the pupil about ether waves, he will still have a very imperfect notion of what the ether is, or how waves are propagated in it. And if we spend more time and effort on this part of the theory of light, we shall have less for studying facts directly—optical instruments, color phenomena, etc.,—or else we must sacrifice some other topic in the course. This remark applies especially to reason number 1.

With regard to Mr. Cavanagh's second reason, I should like to ask what explanation we are to give for the reflection of waves. The fact is that each ether particle (or point in the ether) at the reflecting surface becomes the center of a new wave front, and that the resultant wave-front is the envelop of all these new wave-fronts. Shall we tell that to high school pupils? We cannot use the term "envelop" until they have studied a little calculus, so we must get some other way of making a plane wave-front (or whatever its shape may be) out of an infinite number of curved wave-fronts. This may not be very difficult, except when both the mirror and the incident wave-front are curved, but it certainly will take more time than we use by the geometrical method. And in the end, the pupil will have no reason for taking this envelop rather than any other surface drawn through the new wave-fronts, until you explain the effect of interference. And, finally, we have still not really told how or why the wave-motion is reflected at the surface. We have simply asserted that it is. We can do that much by the geometrical treatment. I submit that this does not really explain what takes place at the reflecting surface; and indeed (I ask for information) are we not obliged to assume that the ether does suffer a stress and strain analogous to the bounding ball? Is not a disturbance reflected back through the ball in just the same way, and is not the fact that the angle of reflection equals the angle of incidence in the case of the ball due to exactly the same cause as with the ether waves, viz., interference?

One statement is surely a slip. On p. 295 he says: "When a wave-front falls on a polished surface, it is reflected as a wave-front. Its velocity may or may not be changed." Surely we are obliged to assume that the velocity is never changed by reflection. That is the only possible way to construct his Fig. 1, e. g. (And by the way, he does not explain how the center  $A'$  is found. Apparently it is done by locating enough points on the reflected wave-front to decide that it is going to be a circular arc, and then by geometry finding the center of this.)

His Fig. 2 is good, but in Fig. 3, I submit that it is not half so easy for a pupil to determine the exact curvature of the refracted wave-front as to determine the direction of the refracted ray.

Again, Mr. Cavanagh's objection to the use of trigonometric functions "before they are understood," can just as well be used to show that a taste of trigonometry should be given to the pupil as to show that the sine definition of the refractive index should not be used. And indeed, this seems to be demanded anyway. (See, e. g., *The Electrical World*, March 30, 1907. p. 620.)

In conclusion, Mr. Cavanagh admits that the wave-treatment "does not lend itself well to quantitative demonstrations." But he is willing to give up such demonstrations for the sake of a method which, after all, does not give an ultimate explanation of any of the phenomena.

Respectfully yours,

WM. B. BORGERS, A.B.,  
Teacher of Physics, Central High School.  
Grand Rapids, Mich.

#### ARTICLES IN CURRENT MAGAZINES.

*American Naturalist* for March: "Studies on the Ophioglossaceæ," Prof. D. H. Campbell; "Polygamy and other Modes of Mating among Birds," Dr. R. W. Shufeldt; "On the Wood Rails, genus *Aramides*, occurring north of Panama," Outram Bangs.

*American Inventor* for April: "The Call of the Sky," "The Modern Torpedo," "How Candles are made," "North Carolina's New Waterway."

*Condor* for March-April: "Among the Pelicans" (photos), Wm. L. Finley; "Migration and Nesting of the Sage Thrasher," M. French Gilman; "An Experience with the South American Condor," Samuel Adams; "Nesting Ways of the Western Gnatcatcher," Harriet Williams Myers; "The California Distribution of the Roadrunner," Joseph Grinnell.

*Farming* for April: "Planting the Small Grains," J. I. Schulte (photographs by the author); "The Farmer's Garden," W. R. Beattie (photographs furnished by the author); "Reclaiming an Unprofitable Orchard," C. G. Woodbury (photographs by the author and S. W. Fletcher); "The Great Value of Japan Clover to the South," C. B. Smith (photographs by the author); "Sweet Potatoes in Western Kansas," Viola McCollm (photographs by the author); "Big Raspberries and Blackberries," W. H. Jenkins (photographs by the author); "Making a Cranberry Boz," A. S. Atkinson (photographs by A. Radclyffe Dugmore and Dr. Frank Overton); "An Alfalfa Experience in New York State," M. W. Jenkins (photographs by W. H. Jenkins); "Commercial Muskmelon and Cucumber Growing," Lyman H. North; "Planting Table for Farmers and Gardeners."

*Journal of Pedagogy* for Dec.-March: "The Organization of the Department of Education in Relation to the Other Departments in Colleges and Universities," "The Relation of the Department of Education to Other Departments in Colleges and Universities."

*Literary Digest* for April 27: "Light as an Enemy to Panama Diggers," "A Detector of the Invisible," "Is Paranoia Curable?" "Our Railroad Breaking Down," "Life-saver for Mercury-workers," "The Founder of Modern Synthetic Chemistry."

*Ores and Metals* for April 20: "Cutting Down Cost of Ore Production," "Industrial Value of Aluminum and Aluminum Minerals," "Role of Copper in Future of Colorado," "Topography of South Platte Valley," "The Principles of Copper Smelting," "Possible Dangers in Increasing Gold Pro-

duction," "New Camps of Nevada," "Facts About the Big Horns," "Geology of Montana Mines," "Mendeleef's Last Prophecy."

*Photo-Era* for April: "The Third American Photographic Salon," William Howe Downes; "The Gum-Bichromate Process," B. F. Langland; "Bromide Prints by Contact," T. H. Ferguson; "Elmwood," W. Prentiss Parker; "The Camera in Science," Frank Collins Baker; "Kallitype for Winter Landscapes," James S. Escott.

*Physical Review* for April: "On the Magnetic Behavior of Certain Nickel Alloys," "Rotation and Elliptic Polarization produced by Iron Films in a Magnetic Field," "The Percentage Bridge," "A Spectrophotometric Study of the Absorption and Fluorescence of Resorufin."

*Popular Science Monthly* for May: "The Jamaica Earthquake," "Notes on the Development of Telephone Service," "The Value of Science," "Is the Mind in the Body?" "Drug Abuses and their Effects on the People," "Illusions of Vision and the Canals of Mars."

*Reviews of Reviews* for April: "The Newest Washington Department," "The Transvaal Restored to the Boers," by W. T. Stead (with portraits); "The Doctor in the Public School," by John J. Cronin (with illustrations); "Pittsburg's Home of the Fine Arts," by Frank Fowler (with illustrations); "The Making of a Forest Ranger," by Arthur Chapman (with illustrations); "Chicago's New Judicial System," by Stanley Waterloo; "The Protection of Life on Railroads: I. 'Reducing the Railroad Death Rate,' by Arthur McFavish; II. 'Railway Accidents and Personnel,' by Wyatt W. Randall; III. 'Psychology of Railroad Accidents,' by Charles R. Keyes; "The Immigration Laws of 1907," by William S. Rossiter; "Japan and Our Wage-Earners," by Harris Weinstock.

*Science* for April 19: "The Sanitary Engineering Problems of Water Supply and Sewage Disposal in New York City," "Upon the Teaching of the Subject of Respiration." For April 26: "Present-day Conditions and the Responsibility of the University," "The Chemist and the Community," "Anthropology at the New York Meeting," "A Plant Tumor of Bacterial Origin."

*Scientific American* for April 6: "The Evaporation of Solid Metals and their Compounds," "The Construction of a Magnetic Detector," April 13: "Seal Hunting on the Floes of the North," "The North Carolina-Virginia Inland Waterway," "The Carnegie Technical Schools, Pittsburg," April 20: "A Harvest of the Sea," April 27: "Australian Sapphires."

*Scientific American Supplement* for April 20: "The rate of Recession of Niagara Falls," "How Coke is Made," "Foundation Problems in New York City," "The Evolution of the Elephant," April 27: "How Coke is Made," "Rate of Recession of Niagara Falls."

*Technical World* for May: "Pioneers of Progress," "To Drain the Florida Everglades," "New Wizard of Power," "Make Money Growing Weeds," "Man's Fight with a Monster," "Taking the Beet's Crystal Gift," "Life-Saving Dogs of Paris," "New Wealth from the Sea," "War Against the Silent Death," "Engineering Progress," "America's Pearl-bearing River."

*Zeitschrift für den Physikalischen und Chemischen Unterricht* for March: "Vorschläge zur Hochschulausbildung der Lehramtskandidaten für Physik," "Über Schul-Mehrbrücken," "Ein Apparat zur Demonstration langsam fortschreitender Wellen," "Beiträge zur geometrischen Optik," "Einfache Versuche zur Demonstration der Lichttelephonie," "Über einen Apparat zum Beweis des Coulombschen magnetischen Gesetzes," "Einige physikalische Vorlesungsversuche," "Einige Bemerkungen über die Verwendung des Calciummetalles beim Unterricht."

Biologists who have used the stereopticon in their lecture and class work have long been looking for a book which would tell them how to do this work to a better advantage. Professor Aaron H. Cole, of the Chicago Normal School, who without doubt is the highest authority on biological lantern projectors in this country, has just written a *Manual of Biological Projection and Anesthesia of Animals*. This book is being published by the Neeves Stationery Company, 543 West 63rd Street, Chicago, Ill., and will be ready for mailing July 1st. Price, \$1.50. See the advertisement on another page.

### DRAINAGE OF SWAMP LANDS.

There are in the United States over sixty million acres of swamp lands. Now that agricultural lands are becoming scarce and the Government has shown what it can do to water the barren deserts of the West, the people of the country are beginning to realize that the Government might be equally successful in removing superabundant water. The fact has been established that by drainage these waste swamp lands may be rendered habitable and productive. Since the Government has set aside millions of dollars for the reclamation of the desert lands of the arid west through the agency of irrigation, this fact is specially interesting, for the vast swamps of the lower Mississippi Valley and of Florida, of the Sacramento valley of California, or the portion of the country once covered by the Wisconsin ice sheets, and the southeastern coastal plain are now the great remaining sources of future agricultural lands.

The effort to drain swamp lands began, like the movement to irrigate the deserts, with the individual, was taken up by the corporation or colony, and is now fast becoming the concern of the State. In northern New York, Ohio, and Wisconsin corporations as well as individuals have drained some of the larger swamps and now raise in them the finest quality of celery, onions and asparagus. In California the State has aided in draining the tule lands, as the extremely fertile swamp lands of the lower Sacramento valley are called. Here are grown crops of asparagus, onions, and other vegetables that love rich and moist soil. In Florida a Governor has recently won an election on the drainage issue, and the people of that State are hoping to drain not only their more accessible swamps but possibly even the great Everglades. In Minnesota and North Dakota a State drainage commission has been organized and vast areas are being drained and settled under State auspices.

Evidence of the extent to which drainage has already been undertaken in a small way by individual farmers is afforded by a comparison of the preliminary editions of topographic maps made by the Geological Survey of areas in Wisconsin with the final topographic sheets of the same areas. The final sheet of the Koshkonong quadrangle, for example, made in 1903, shows a great diminution in the original area of swamp land, as represented in the reconnaissance survey of 1887. An examination of the two maps indicates clearly, in the light of what has since occurred, how a study of the earlier sheets would have suggested possible lines of drainage ditches. Differences of elevation recorded on the map have indicated to an engineer the probable results of constructing drainage ditches in certain places. The new sheet of Madison, Wis., quadrangle, just issued, shows not only what has been done by private enterprise, during the past fifteen years, in the way of draining swamps, but indicates what may be done to drain other thousands of acres of swamp land.

Few people realize how valuable these topographic maps may be in furnishing accurate data on which to base plans for improving swamps

and marshes. On these sheets a general drainage plan may be laid down and the feasibility of the proposition definitely determined without preliminary surveys. The maps afford an opportunity for the comprehensive study of each case without regard to State or County boundaries. A good illustration of the usefulness of these atlas sheets is afforded by the recently surveyed Linesville (Pa.) and Andover (Ohio) quadrangles, which show Pymatuning swamp. This covers an area of about 8,000 acres in Crawford County, Pa., but drains through Shenango Creek into Ohio and back again into Pennsylvania, and at one time furnished water for the summit level of the abandoned Pittsburgh and Lake Erie canal. This land is at present nearly worthless, though by proper drainage it may be rendered exceedingly fertile. Ashtabula Creek, heading a little south of the village of Pennlin, has a greater fall than Shenango Creek, the natural outlet, but it is separated from Pymatuning Swamp by a ridge about forty feet in height. Should detailed examination of the material of which the divide is formed prove favorable, Ashtabula Creek might be utilized in draining the swamp lands, and a much larger area thus be reclaimed.

This is only one of dozens of similar areas mapped by the Geological Survey in which enough information has already been collected to make a substantial beginning for studies in drainage. The really important marsh areas such as the Dismal Swamp, the Florida Everglades, and wide reaches in Minnesota are yet to be mapped, and until the work is done, no comprehensive plans for their drainage can be perfected.

The possibility of improving these lands is only beginning to interest people in this country. Abroad, much more attention has been given to these questions. In the United States most efforts in this direction are the result of private enterprise. In only a few cases have examinations been made by County and State authorities. Unfortunately, there are millions of acres of swamp land so situated that their drainage would involve the outlay of hundreds of thousands and even millions of dollars. Such vast undertakings can not be financed by private individuals nor even by States. The aid of the Federal Government is necessary, especially in view of the fact that most of these wet lands have been patented in trust to the States with a view to their drainage by State aid, or are still in public ownership.

The topographic maps of the Geological Survey constitute a wealth of material on which to plan drainage works, but the Government should now go a step further and direct the energies to the topographers more immediately into swampy regions. It is possible that the result of such surveys will show up enough reclaimable land to warrant the enactment of federal legislation for the general drainage of existing swamps. Without such aid millions of acres of the richest land must remain waste, while the settlers on our western desert lands are being helped to fortunes. All of the sixty million acres of swamp lands in the country can not of course be reclaimed by drainage.—*United States Geological Survey Bulletin.*

### MEETING OF THE MATHEMATICS AND PHYSICAL SECTION OF THE ONTARIO EDUCATIONAL ASSOCIATION.

The Annual Meeting of the Mathematical and Physical Section of the Ontario Educational Association was held in the Physics lecture room of the University of Toronto, on April 2nd and 3rd. The following program was carried out:

Tuesday.—President's address "Modern tendencies in the teaching of Secondary Mathematics," H. S. Robertson, Stratford Collegiate Institute; "The Poetry of Mathematics," Wilson Taylor, Chatham Collegiate Institute; "Integers, finite and infinite," Prof. W. Findlay, McMaster University.

Wednesday.—"Mathematics as a means of Culture," Prof. Alfred Baker, University of Toronto; "Junior Leaving Arithmetic," J. S. Wren, Harbord St. Collegiate Institute, Toronto; Discussion of the 1906 Problem Paper, J. T. Crawford, Hamilton Collegiate Institute; "The Transformation of Matter," Prof. Rutherford, F.R.S., McGill University.

The following officers were elected for 1907-08:

Hon. President, Prof. Alfred Baker, University of Toronto; President, C. L. Cressweller, Sarnia Coll. Inst.; Vice-President, Wilson Taylor, Chatham Coll. Inst.; Sec'y-Treas., R. Wightman, Jarvis St. Coll. Inst. Toronto; Councillors, G. H. Hogarth, W. Findlay, A. W. Overholt, J. rS. Wren; Library Committee, Prof. DeLery, Prof. London, Chancellor McKay, Dr. Birchard, H. S. Robertson.

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### CENTRAL IOWA ASSOCIATION OF SCIENCE AND MATHE- MATICS TEACHERS.

The third meeting of this Association was held in conjunction with the Iowa Academy of Science, at Drake University, Des Moines, April 26-27.

At the joint meeting Friday evening Professor H. L. Russell of the University of Wisconsin gave a most interesting and helpful address on "Recent Discoveries with Reference to Insect-Borne Diseases."

After the general meeting Saturday morning the Association divided itself into section meetings on Chemistry, Mathematics, Earth Science and Physics. These section meetings were in the nature of round-table talks, no set papers being read.

In the Chemistry section the discussion centered on: Chemistry in the High School, Theoretical Chemistry, The Chemical Equation and Qualitative Analysis. Many new points were brought out to those in attendance.

The Mathematical Section had for its topics the following:

1. The High School Course in Mathematics.
2. Trigonometry in the High School.
3. What can be done to develop a student who, having reached the age of reason, has not acquired the power of reason; or help the

student who is lacking in independent methods of investigation?

4. To what extent is individual work with a student helpful or harmful?

5. Do frequent examinations in mathematical studies tend to increase thoroughness?

6. What can be done to induce students to be more careful and accurate in explanation i. e. to give reasons and explain methods rather than read equations?

7. In teaching arithmetic, what can be done to form in young pupils' minds a clear concept of units of measure, such as rod, acre, etc.?

8. The laboratory method.

Spirited talks were given by many present, and all received an inspiration.

The Earth Science Section had for subjects to be discussed, Physiography, Weather Observations, Field Work, Physiology, Biology, and the Science Teacher.

The Physics Section centered its talk around the three timely themes: The Physics Unit, Laboratory Supervision and the Laboratory Note Book.

Many who attended these meetings expressed themselves as having received as much help in their respective lines of work as in any meeting of the kind which they ever attended.

C. H. S.

### INDIANA ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

The twelfth annual conference of the Indiana Association of Science and Mathematics Teachers was held in Indianapolis Fri. and Sat., April 26 and 27, and in some respects the meeting was of unusual interest.

The general session was held on Friday at 2 p. m. in the Manual Training High School. Leonard Young of Evansville, Pres. of the Association, delivered the annual address. The subject was a general consideration of the teaching of physics, and set forth many points of interest relative to this phase of science work.

The speaker thinks (1) that a broader view should be given to some details of the subject of Physics rather than attempting to cover too much ground.

2. Teachers should have some latitude in choosing those parts of the subject best adapted to the subject and environments.

3. Experimental work should not be made too easy, but should require close thinking and should mean something when completed.

4. The industrial and concrete side of physics should have as much prominence as possible.

At the close of this address the subject of "Laboratory Physiography" was discussed by L. C. Wessel of Huntington, followed by a paper on the subject: "Shall Science work in Secondary Schools have a strong economic bearing?"

This subject brought forth a spirited discussion, which showed that those present were fairly well divided as to the desirability of making this grade of science work too economic in its bearing.

The Friday evening session was held in the Shortridge High School and consisted of a lecture by Dr. H. E. Barnard, state chemist, on "Food and Drug Adulteration from the Laboratory Standpoint." This meeting was preceded by an exhibition of the reflectoscope, which method of projection is becoming of great interest and value in science work. The work of Saturday forenoon was conducted in three section meetings held in Shortridge High School. In the Physics and Chemistry section, which was presided over by Dr. Naylor of DePauw University, the following subjects were discussed:

1. "Ions from the Chemist's standpoint," Geo. A. Abbott, Indianapolis.
2. "Ions from the Physicist's standpoint," Prof. J. A. Culler, Miami University.

3. Round Table. Subject: "Should the work in Physics in the High School be more intensive or more extensive in its scope?"

Prof. M. B. Thomas of Wabash College had charge of the Biology section in which five excellent papers were presented as follows:

1. "Zoology in the High School," U. O. Cox, State Normal.
2. "Vitalizing Biology," Will Scott, Bloomington.
3. "Some aspects of a High School course in Botany," H. F. H. Meier, Muncie.
4. "Field Work in Biology," A. M. Mahaffey, Columbus.
5. "Ten experiments with Plants with simple apparatus," H. S. Voorhees, Ft. Wayne.

The Mathematics section was in charge of Robert McDill, New Castle. This section considered the following subjects:

1. "Suggestive changes in the High School courses of study in Mathematics," Walter W. Hart, Indianapolis.
2. "Teaching mathematics to the Philipinos," Miss Mabel Bonsall, New Albany.
3. "Preliminary Report on Defective Grade Teaching of Mathematics," J. T. Giles, Marion.

The work in these various sections brought out some valuable discussions, which continued much beyond the noon hour, thus showing the interest taken by the members present.

A number of new members were added to the association and the following officers were elected for 1908:

O. W. Douglas, Pres., Anderson; L. C. Ward, V-Pres., Huntington; J. F. Thompson, Sec.-Treas., Richmond; G. A. Abbott, Chairman Ex. Com.

It is proposed to send a large delegation from Ind. next Nov. to the St. Louis meeting of the Central Assn. of Science and Mathematics Teachers in order that some influence may be brought to bear on bringing the meeting for 1908 to Indianapolis.

W. A. FISKE.

Structure and Physiology of Flowering Plants, students Guide, by S. O. Mast, Ph.D., Prof. of Biological Science Hope College. 1907. Pp. 54. Published by the author, Holland, Mich.

Problems in Chemical Arithmetic by Nicholas Knight, Professor of Chemistry Cornell College, Mt. Vernon, Iowa. 1906. Pp. 12.

Exercises in Botany for High Schools. 16 pages. 1907. W. L. Eikenberry, St. Louis. Published by the St. Louis Biological Laboratory.

Laboratory and Field Manual of Botany, by Joseph T. Bergen and Bradley M. Davis. 12mo. cloth. 257 pages. Mailing price, \$1.00. Ginn & Co., publishers.

Annual Report of Board of Education, Kansas City, Mo. Press of R. H. Bolding.

Questions and Problems on Chemistry, by Franklin Turner Jones, University School, Cleveland, O. Price, 30 cents.

Problems and Questions on Physics, by Franklin Turner Jones, University School, Cleveland, O. Price, 30 cents.

Catalogue of Reference Books in Physics for Secondary Schools. (See review this issue.)

Catalogue Central Scientific Co., 14-28 Michigan Street, Chicago. Pages 308.

Bulletins of Summer Sessions of: University of Wisconsin, University of Illinois, Cornell University, and University of Chicago.

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#### BOOK REVIEWS.

CATALOGUE OF REFERENCE BOOKS IN PHYSICS.—Suitable for Secondary Schools. Revised Edition. Compiled by a Committee of the Eastern Association of Physics Teachers, 1907. Pp. 47.

The list is primarily designed to be a guide and help to the teacher in selecting his reference library. 161 Books are named. Under each title is given data regarding size, price, date, publisher and a well-written comment by a teacher familiar with the book.

The following lists are given: General Treatises, Mechanics, Heat, Light, Sound, Electricity, Laboratory Work, Tables, Historical, Technics, Text-books, Publishers of Scientific Books. A list of books costing \$30, and a second list of books costing \$60.

This is the most valuable and up-to-date list of books in Physics published. Every Physics teacher should possess such a list.

It can be obtained by sending 35 cents to the Secretary of the Association, F. G. Jackson, Dorchester High School, Boston, Mass.

C. M. T.

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#### *Reports Published by Association of Mathematics Teachers of New England.*

The Association of Mathematics Teachers of New England has recently published its third report. It is the "Second Report of the Committee on Arithmetic," and consists of suggestions for correlating drawing, arithmetic and observational geometry. The general classes of geometrical truths that grammar school children should know to

gether with suggestions as to methods of presentation, a set of constants to be used in connection with applications of the Pythagorean Theorem, the usual formulae for areas and volumes and suggestions for correlating drawing and arithmetic by means of graphs, are given. These latter are especially interesting; some twenty-six questions and problems appear, with eight diagrams. The report contains sixteen pages.

The preliminary report of this same committee was presented in 1906; it endorsed the Walter system, recommended some useful and practical methods of checking for accuracy, suggested the exclusion of certain outworn topics, and drew up outlines for teaching Reversed Multiplication and shop subtraction.

The "Final Report of the Committee on the Fundamental Propositions of Elementary Geometry" also appeared in 1906.

These reports are on sale by the treasurer for six cents each. Address, William B. Carpenter, Mechanic Arts High School, Boston, Mass. M. S.

*Problems and Questions on Physics.* By Franklin Turner Jones, University School, Cleveland, Ohio. 40 pages. Wholesale price or teachers' sample copy, 30 cts.

This little book is just from the press. It consists of two parts. Part I contains 446 well-selected problems and questions compiled from examination papers of Case School of Applied Science, College Entrance Examination Board, Cornell University, Harvard University, Massachusetts Institute of Technology, Princeton University and Sheffield Scientific School of Yale University.

The general order of topics is: Mechanics of solids, Mechanics of fluids, sound, heat, magnetism, electricity and light. These questions, selected from the papers of several first-class schools, will be helpful to the physics teacher and pupil in preparing the pupil for entrance examination into any school.

Part II is composed of 104 well-chosen questions for review covering the entire field of secondary physics. These questions contain much meat and food for thought and work and will greatly assist any instructor in giving his class a thorough review.

The booklet could well be used as a text-book in the hands of every pupil of physics. A mastery of its contents will put a person in position to pass any given entrance examination in this subject.

All physics teachers should possess a copy of this booklet. C. H. S.

#### ERRATA.

In the April 1907, number, page 313, line 10,  $ab = ba$  should read *ab is not equal to ba*, and in line 31,  $ab$  should read *ab is not equal to ba*.